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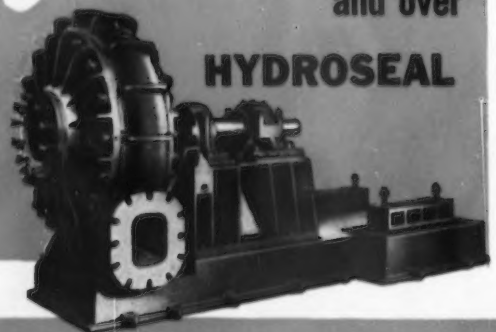

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89th YEAR OF PUBLICATION

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LETTERS

Open-Pit Response

How about covering all mining operations? Keep up the good work, I think *EM&J* gets better every month.

Harold C. Hiebert
Reedley, Calif.

Should be made an annual feature.

B. L. Boggess
Golden, Colo.

Will get top location in our files. We need more of them.

G. C. Moore
Los Angeles, Calif.

• **E&MJ will publish a Guidebook Issue and Buyer's Guide annually.—Ed.**

Would like to see more on exploration . . . potential areas and types.

Harry Nedwick
Ruth, Nev.

• **See page 6.—Ed.**

Suggest exploration techniques . . . geophysics . . . mainly drilling, etc.

O. H. Wright
Bartow, Fla.

Would appreciate guidebook concerning geological and geophysical aspects and developments.

George W. Starch
Ajo, Ariz.

Another guidebook might include "prospecting and exploration."

Ford W. Knight
Anaconda, Mont.

How about a guidebook on geophysics?

Bruno Hahmann
Apiai, Brazil

• **Pages 19, 25 and 50.—Ed.**

We would appreciate an *E&MJ* Guidebook on underground mining, and possibly on administration and safety.

The General Manager
Kimberley, South Africa

(Let's have some) on concentration and underground mining.

Ed Joseph
Norwood, Colo.

• **See page 33.—Ed.**

We would like guidebooks on concentration and metallurgy.

Gmelin-Institut
Clausthal, West Germany

(Please publish a guidebook covering hydrometallurgy.

Russell C. Nelson
Towanda, Pa.

Would like a similar guidebook on hydrometallurgy.

W. R. Brown
Nicaro, Cuba

• **See page 52.—Ed.**

May we have your comments on this Guidebook? Reply card opp. p. 82.

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P-17A

ENGINEERING AND MINING JOURNAL

MID-MARCH 1955

Another E&MJ Mining Guidebook Issue At Your Request

LAST MAY, ENGINEERING & MINING JOURNAL published its first guidebook—the Open Pit Mining Guidebook—as a venture in a new field of editoral service to you. Then we asked for your frank opinion about the guidebook, whether you wanted another one, and, if so, on what subjects. Hundreds of replies came to us requesting more guidebooks on virtually every phase of the mining industry.

So at your request, here is your 1955 *E&MJ* Mining Guidebook issue, designed to interest all readers, from the exploration engineer in search of ore to the metallurgist producing the final refined ingot.

The authors who have written the major portion of this guidebook are widely respected for their competence—a competence demonstrated by their ability to apply science and technology to find ore, mine efficiently, concentrate and extract metals and minerals, or design new and modern equipment and plants that really work.

The subjects which the authors have presented are significant, useful, forward-looking and thought-provoking. We can assure you that you will not breeze through this issue. For one thing, it contains three times as many pages of technical articles as a regular issue. Secondly, the authors have packed a lot of stimulating ideas and data into their articles, and if you read between the lines, you will find the articles doubly significant. See comments on the articles, pages 97 and 98. The volume of illustrations has been so large that preparation of drawings and maps in easy-to-read form has been in process for over five months.

This guidebook is particularly unique in that it is not a review issue or a comprehensive handbook.

Again at your request, we have included a Buyer's Guide section, classifying equipment supplies and services offered to the mining industry. More than 1500 questionnaires were sent out to insure accuracy and proper classification. A list of manufacturers' names and addresses is included, conveniently indexed so that you can refer to their messages of specific interest in the concluding sections of this guidebook.

Once more we invite your comment via the return postcard inserted between p 82 and 83.

FIG.1 Principal sources of domestic copper, lead, zinc, gold and silver production for 1907-1953 inclusive by mining districts. Prepared from U.S. Bureau of Mines Statistics.

MORE THAN 90% of the domestic gold, silver, copper, lead and zinc produced in the U.S. during the past 50 years came from the mining districts indicated above. Aggregate area of the ore deposits in these districts is less than 1,000 sq mi.

Prospecting and Developing Ore Deposits in Bedded Formations

GEORGE M. FOWLER
ROBERT M. HERNON
JOHN M. CONROW
EDWIN A. STONE

THE PROSPECTING AND DEVELOPMENT of ore deposits depend upon many related factors, some of which are discussed here. The problems are being solved gradually, but the final answers lie in the future. Ore seekers are increasing their understanding regarding structural deformation and its relationship to ore deposits. New techniques are gradually being developed and tested.

Team work in ore production is a requisite that is gained through close cooperation between management, geologists, engineers, and those who actually mine the ore. Many nontechnical people are excellent observers, and the success of a number of the projects discussed here was due in part to the practical application of knowledge gained by such observers as the investigations progressed.

Stratigraphic and structural interpretations demonstrate a definite relationship between geologic structure and ore deposition and make distinctions between barren, potential, and definite ore-bearing formations possible. Such information has been used effectively to reduce exploration and development costs. These methods have wide application.

Adequate stratigraphic knowledge of the formations in which ore deposits are localized is a requisite, particularly if thick bedded (competent) and thin bedded (incompetent) strata are present.

For many years the writers have continuously worked with groups of geologists in seeking and developing ore deposits. Hundreds of mines and prospects were examined in order to gain knowledge regarding their ore localizations. These studies were largely in stratified formations, but many ore deposits in massive rocks also were examined and appraised. The investigations extended into nearly every major and scores of minor mining districts and mines in the United States, and into many mines in Mexico and Canada. Published data pertaining to some of this work relate chiefly to geology and ore deposits. Procedures in defining and appraising the ore deposits were only briefly discussed. Here the steps employed in some of these ore search activities are recorded and examples cited.

Essentials for Ore Deposits

Among recognized essentials for hypogene ore deposits are:

1. Source materials and
2. Passageways for the transfer of the source materials from their original loci to
3. Ore reservoirs.

The adequacy and inadequacy of all of these essentials are limiting factors in any ore deposit. The volume of the ore deposits is definitely related to quantities of source materials and cubical contents of ore reservoirs. Optimum conditions require abundant source materials, and adequate passageways and ore reservoirs.

Practically all domestic ore discoveries resulted from surface manifestations in and around them. The search has been widespread and intensive, and few such new discoveries will be made. New reserves must be found, and they will be won from now obscure ore deposits. The clues for new ore discoveries will often be gained through adequate understanding of regional and local structural deformation obtained from surface exposures and from drill holes. Various geophysical methods are being applied successfully in conjunction with some of these efforts.

Structural Deformation and Ore Deposits

Approximately 40 districts (see Fig. 1) were the sources of more than 90% of the domestic gold, silver, copper, lead, and zinc produced during the past 50 years. The aggregate area of the ore deposits within these districts collectively is less than 1,000 sq mi as they occupy only small parts of the respective districts. Thousands of widely scattered small mines and many districts in zones of minor deformation supplied less than 10% of these metals. These major and minor districts have been prospected sufficiently to show that their comparative ore production ratios will remain constant.

The general relationship of structural deformation to ore deposits has been recognized and used in some degree in ore search investigations for several hundred years. During the present century less costly ore search methods, increased study facilities, greatly expanded fields for observation, and many other factors, have given impetus to ore search investigations. Many present ore seekers rely chiefly on the structural deformation-ore deposit relationship to guide them to new discoveries. Structural deformation of some character is a requisite for formation of ore reservoirs, but other factors are always present and some are recognizable.

All important domestic non-ferrous mining districts known to the writers originated because they were loci of major and unusual structural adjustments. These adjustments formed both reservoirs and passageways that connected them with sources of ore-bearing media.

Importance of Stratigraphy

Adequate stratigraphic knowledge of formations in which ore deposits localized is a requisite, particularly if thick and thin bedded strata are present. Generally thick bedded strata are competent, and thin bedded strata are incompetent under folding stress. Either or both may be incompetent under stresses producing shearing or tensional deformation. In such environments ore generally localized in shear or fissure zones that transect the strata and as bedded deposits that replace part of the incompetent strata. Structure contour maps on key horizons greatly simplify many problems.

Structural deformation materially controls the outline of ore deposits in stratified formations. Where flexures are absent or of small amplitude, stresses parallel to the strata produced blanket-like ore reservoirs. Such reservoirs are also present at some unconformities, particularly if slightly uneven or serrated, as in parts of the Oklahoma-Kansas mining field. Where flexed strata are present, the ore deposits generally localize in tensional segments and are usually absent in compressional segments. Degree of flexing and manner of application of deforming stress, and brittleness or plasticity of affected rocks, influenced these phenomena. Strata that were flexed beyond their elastic limits sheared and shattered and were the loci of numerous ore deposits, large and small. These conditions exist wherever ore deposits localized in competent and incompetent strata.

Shales and similar formations that are plastic usually flow, then become compact when deformed, and thus lack the sponge-like qualities necessary for ore deposition, However some shales possess or acquire physical and chemical qualities necessary for ore deposition and are important ore sources in mines in southern Mexico and elsewhere.

Ore deposits in bedded formations present some similar structural characteristics wherever located. Blanket-like ore deposits are mined extensively in many parts of the Central States; at Park City and elsewhere in Utah; at Metaline Falls, Washington; in eastern Tennessee; and in many other places. These deposits localized largely in the less competent strata that deformed by flexing and shearing. Consistently competent strata are structurally deformed by shearing and the ore localized in fissures in and contiguous to the premineral shear zones and fissures.

Three General Relationships

In bedded formations that contain ore deposits, structural deformation in three general relationships to bedding is present in many mines in the United States, Mexico, and Canada:

1. Approximately parallel to the bedding.
2. Approximately perpendicular to the bedding.

Stresses oriented in both relationships to bedding were active in some mines and districts. Ore localized in faults or in nearly vertical shearing at one or several stratigraphic horizons, and nearly parallel to the bedding at other horizons.

3. Transecting the strata at low to high angles.

In southeastern United States immense overthrusts transect strata that are miles in thickness. Numerous large and small ore deposits localized in zones of deformation within some of the strata between these thrusts. Such localizations include the Mascot-Jefferson City mining district in east Tennessee, which has produced many million tons of zinc ore, and has large potential zinc reserves.

Many manto deposits in Mexico localized along extensive surfaces of small movement that transected the bedding at angles of a few degrees. Somewhat similar localizations exist in the mines at Bisbee, Ariz.

The original relationship existing between ore deposits and host rocks may be obscured by leaching media that reached the environment through passageways made by structural deformation. Leaching and alteration of rocks and ore by meteoric waters, and consequent rock slumpage that forms new structure patterns, are among the processes that mask or destroy part of structural and stratigraphic features of ore environment. New structural patterns may be super-

Table I. Production of Tri-State district, 1907-1953, inclusive

(Compiled from U.S. Geological Survey and U.S. Bureau of Mines statistics.)

	Material milled (short tons)	Concentrates produced (short tons) Zinc	Lead	Concentrate recovery (percent) Zinc	Lead
From crude ore...	381,734,340	17,109,516	2,762,055	4.48	.72
From old tailings..	152,001,046	1,306,193	10,731	.86	.007
		Recoverable—Metal (short tons) Zinc	Lead	Recovery (percent) Zinc	Lead
Produced, 1907–1953, inclusive					
Tri-State mining district.....		9,296,710	2,147,044		
UNITED STATES.....		26,158,689*	21,635,880*		
Percent of production by Tri-State mining district.....				35.5	10.0

* 1953 production figures used for the United States are preliminary.

imposed on pre-ore patterns by post-ore deformation. Finally, the mineralization process, itself, may destroy part of the original structural pattern.

Influence of secondary alteration on primary sulphides of lead, zinc, copper, and associated minerals is revealed in many mines in limestone and dolomite in southwestern United States and Mexico, and in the Central States and elsewhere. At the Bristol mine, near Pioche, Nev., lead-silver ores are almost entirely oxidized to a vertical depth of more than 1500 ft. The structural pattern of the sulphide ore has been nearly obliterated in some larger ore deposits. Similar conditions exist in many surface and near-surface deposits around Granby in Missouri, Monterrey in Mexico, and many other localities in the United States and Mexico.

Ore deposits in bedded formations are widely distributed. Domestically they are nearly as widespread as the mining districts and are the major source of lead and zinc ores. In massive formations the ore deposits usually localized in shear zones that cut the bedding at steep angles. In composite formations, the ore deposits generally localized in thin-bedded less competent strata cut by shear zones, and further deformed by flexing, shattering, and other agencies. Chemical processes, such as dolomitization, preceded ore deposition in the structurally deformed parts of many mines and the ore localized in parts of the altered rocks.

Central States

For the period 1907-1953, inclusive, the Central States were the source of approximately 44% of the lead and 40% of the zinc produced domestically.

In the Central States the known lead and zinc ores localized in many hundred separate deposits aggregating about 60 sq mi in a region several hundred thousand square miles in extent. This region comprises nearly all of the Ozark uplift which covers southern Missouri and contiguous parts of Kansas, Oklahoma, and Arkansas; parts of southern Illinois and western Kentucky; and large areas in contiguous parts of Wisconsin, Illinois and Iowa.

Four major mining districts were developed in the Central States:

1. The Tri-State mining district comprising contiguous parts of Missouri, Kansas, and Oklahoma.
2. The Southeast Missouri district.
3. The Upper Mississippi Valley mining district comprising parts of Illinois, Wisconsin, and Iowa.
4. The Southern Illinois-Western Kentucky district.

Minor volumes of ore were won from several additional districts and from hundreds of widely scattered mines and prospects in this vast region, but their aggregate production has been very small in comparison with that of the four major districts.

Practically all ore deposits of the Central States are in sedimentary rocks that range up to 2500 ft in thickness above the pre-Cambrian basement. In southeast Missouri the basement formations crop out in a few localities. In the region as a whole, ore deposits are found from the surface to a depth of about 1,000 ft, the average depth being less than 500 ft.

The Tri-State Mining District

The Tri-State mining district, approximately 2,000 sq mi in extent, has been a major source of zinc and lead for many years. For the past 40 years its greatest ore production came from the Oklahoma-Kansas field, a 25-sq mi area one-half of which is ore-bearing. This field, which shows no surface manifestations, was discovered accidentally in 1915; its present gross production exceeds one billion dollars.

Observations in the Tri-State mining district in January 1926, revealed a close relationship between structural deformation and ore deposits. Clues to this condition were noted in several mines, particularly in the Adams mine of the Anna Beaver Mining Co. in the northeast quarter of section 23, Township 29 North, Range 22 East, Oklahoma. Similar conditions have been confirmed in the interim by thousands of observations throughout the Tri-State mining district.

In 1926 the recorded theories regarding the host formations, chert, dolomite, and ore, included syngenetic origin, accumulation from ground waters, and other hypotheses. Little thought had been given to the relationship between structural deformation and the ore deposits.

Stratigraphy

The Boone formation of Mississippian age was deposited in many alternating thick and thin beds as practically pure limestone. It occupies many thousand square miles in southwest Missouri and contiguous parts of Kansas and Oklahoma and contains practically all the ore deposits of the Tri-State mining district. In Mississippian (pre-Chester) time the Boone was deformed and contemporaneously or later was abundantly chertified along the trends of deformation through thousands of cubic miles of strata in the western part of the Ozark uplift. The chert transects or parallels the strata in irregular masses which range in volume from several cubic feet to many million cubic feet.

In the Tri-State mining district, the Boone is approximately 400 ft thick, and all of the ore localized in the zones of deformation that were developed in it. Dolomitization of part of the remaining limestone followed chertification, and is widespread, but the dolomite is in smaller volume than the chert. Ore deposition followed these processes after a long time interval. The chertification cycle probably occurred in early Mississippian time; the early dolomite, the sponge for these ore deposits, followered, but its age is not established. Ore minerals were deposited in post-Pennsylvanian time.

Early in these ore search investigations repeated efforts were made to interpret the stratigraphic problem.

Numerous strata distinguishable underground in limestone zones were seemingly obscure in chert and ore zones. The problem was solved when a stylolitic stratum several inches in thickness was recognized and followed continuously from limestone into chert and an ore deposit. This relationship was first noted about 25 years ago in the Pelican mine, two miles north of Cardin, Okla. and soon became evident throughout the mining field.

Stylolites Indicate Ore

Stylolites are abundant in the less-competent strata of the Boone formation and present in some degree in nearly all of the limestone. Many of the Boone ore deposits are closely associated with stylolites which are generally roughly parallel to the bedding. Various theories have been advanced for their origin and development. In this district and in widespread parts of the Ozark uplift there is abundant evidence that stylolites were formed by lateral stresses that acted progressively, as there are many examples of earlier stylolites cut by those of later origin. They may occur alone or in series from fractions of an inch to several feet or more in thickness. Many of the ore deposits localized in stylolitic strata in zones of structural deformation.

The stratigraphy of the Boone formation and its relationship to the ore deposits of this district presented a problem because the chertification and dolomitization of limestone in and near the ore deposits had partly destroyed fossils and other identifying criteria in the original rock. The necessary knowledge was gained after several years of study of many thousands of drill hole cuttings, logs, and underground exposures. These showed that alteration, including chertification, produced characteristic changes, revealing numerous beds in the Boone formation that are distinguishable through scores of square miles. Generally the distinctions can be made macroscopically, particularly where the strata or cuttings from them are wetted and viewed in sequence across two or more marker horizons. When necessary a low-powered lens was used. Data were thus established on which to build structure contour maps at several horizons. These maps greatly simplified ore search investigations in the region, and they were developed and used throughout the district for determining ore-bearing possibilities and other pertinent facts.

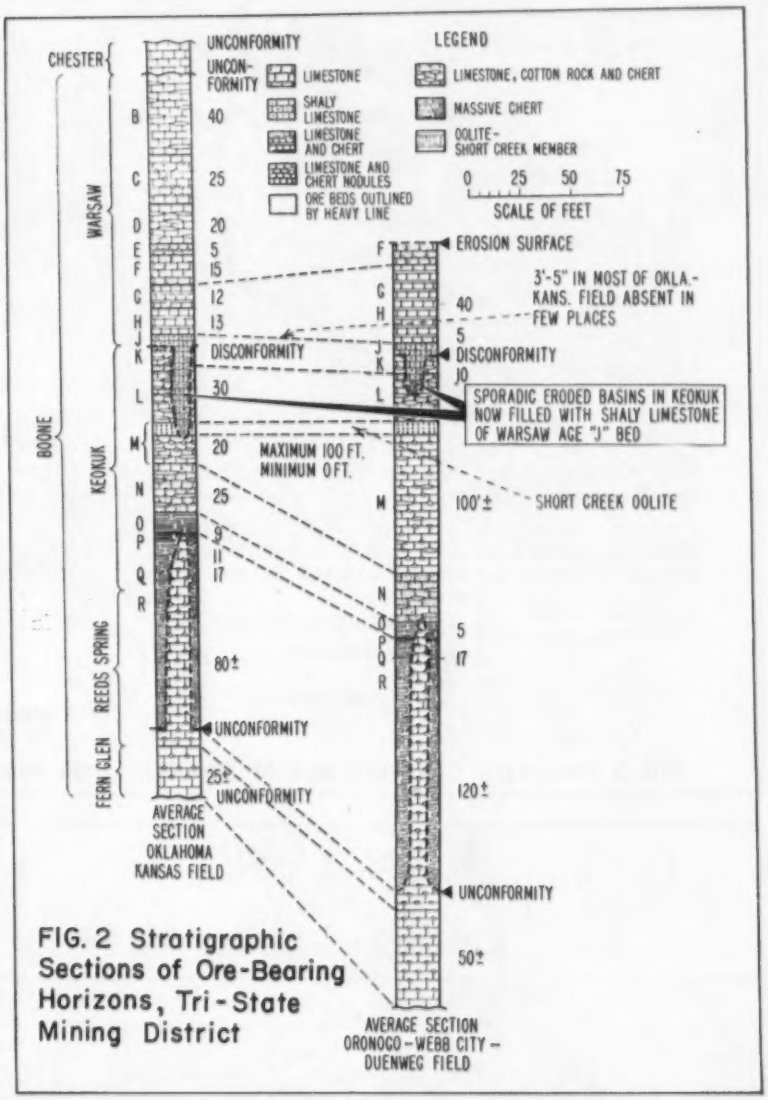


FIG. 2 Stratigraphic Sections of Ore-Bearing Horizons, Tri-State Mining District

STRUCTURE CONTOUR MAPS of several horizons in the above sections greatly simplified the ore search investigations of the authors in the Tri-State district.

Structral Deformation and Ore Deposits

The Miami shear trough is the most prominent structural feature of the district. It trends northeasterly from a point a mile west of Afton, Okla. to Waco, Mo., a distance of more than 40 mi. It intersects the Oklahoma-Kansas field in a series of elongated fault basins that range up to one mile in length, a quarter of a mile in width, and 150 ft in depth.

Another prominent structural trough, the Bendelari, trends northwesterly from the Miami trough from near the center of the Oklahoma-Kansas field, for a distance of about two miles. It ranges to one-half mile in width and its flanks generally dip less than 10 deg. Numerous ore deposits localized in deformed strata in this trough.

Pre-mineral structural adjustments developed flexures, shear zones, and slippage along bedding planes and unconformities. The flexures range in area from a fraction of an acre to many acres, and in vertical amplitude from a few feet to 100 ft. Maximum structural relief in the field as a whole is 350 ft. Throughout the district the deformation, chert, dolomite, and ore transect the strata upward in anticlines and downward in synclines and similar environments.

(Continued on p 12)

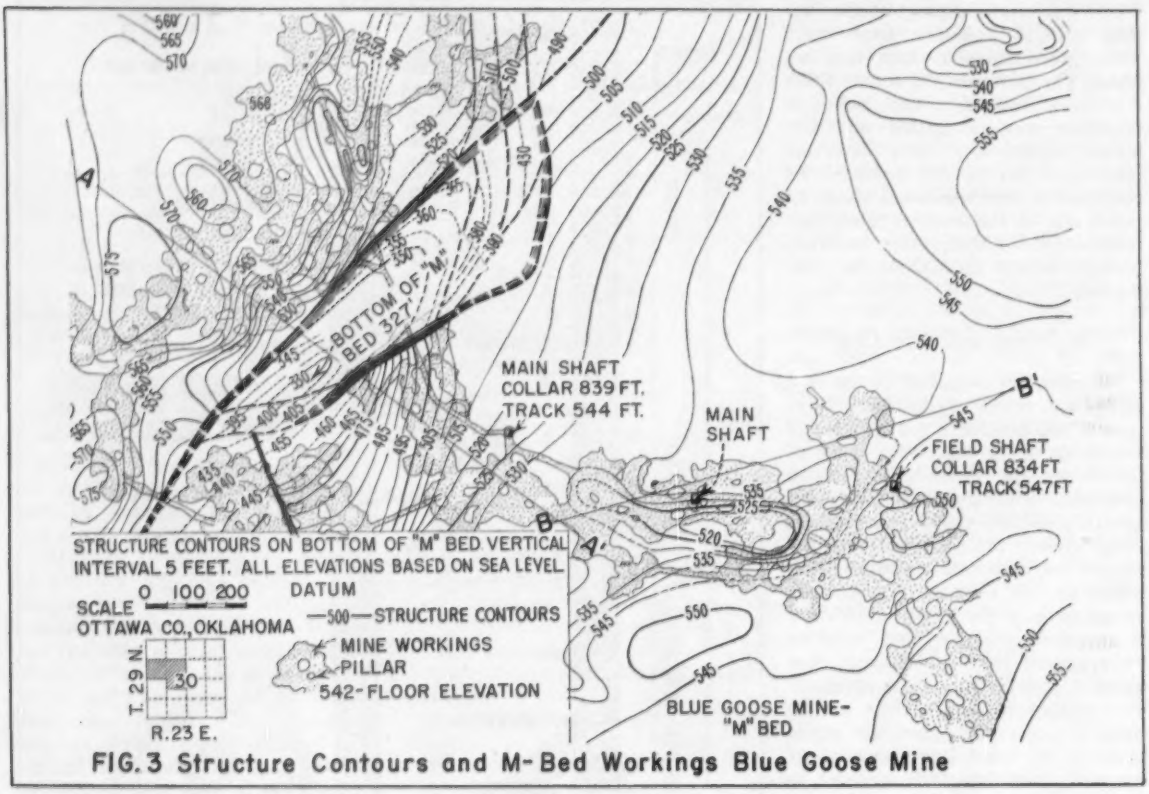


FIG. 3 Structure Contours and M-Bed Workings Blue Goose Mine

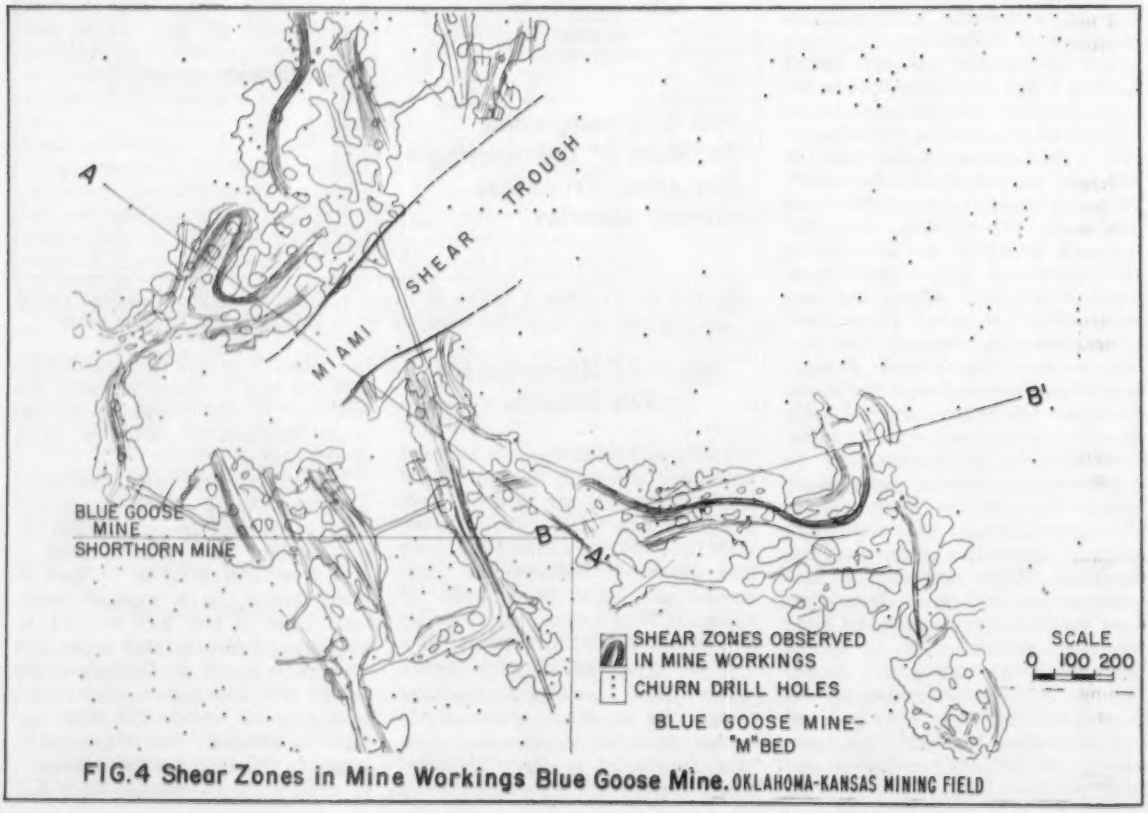


FIG. 4 Shear Zones in Mine Workings Blue Goose Mine. OKLAHOMA-KANSAS MINING FIELD

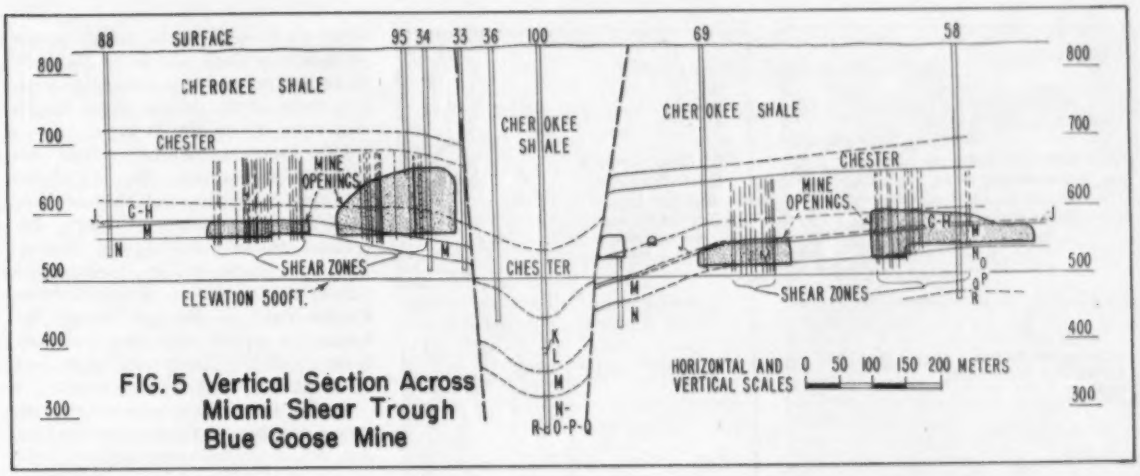


FIG. 5 Vertical Section Across Miami Shear Trough Blue Goose Mine

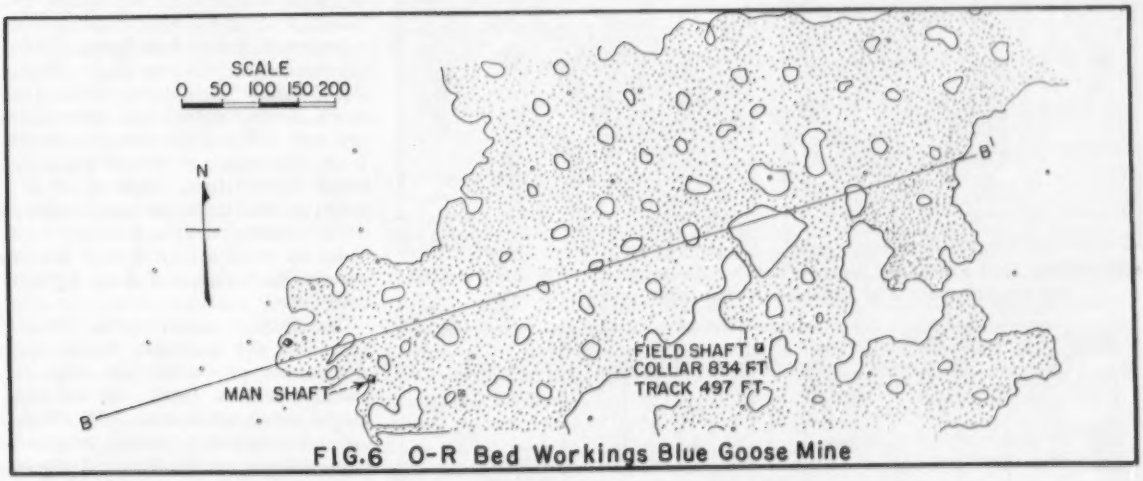


FIG. 6 O-R Bed Workings Blue Goose Mine

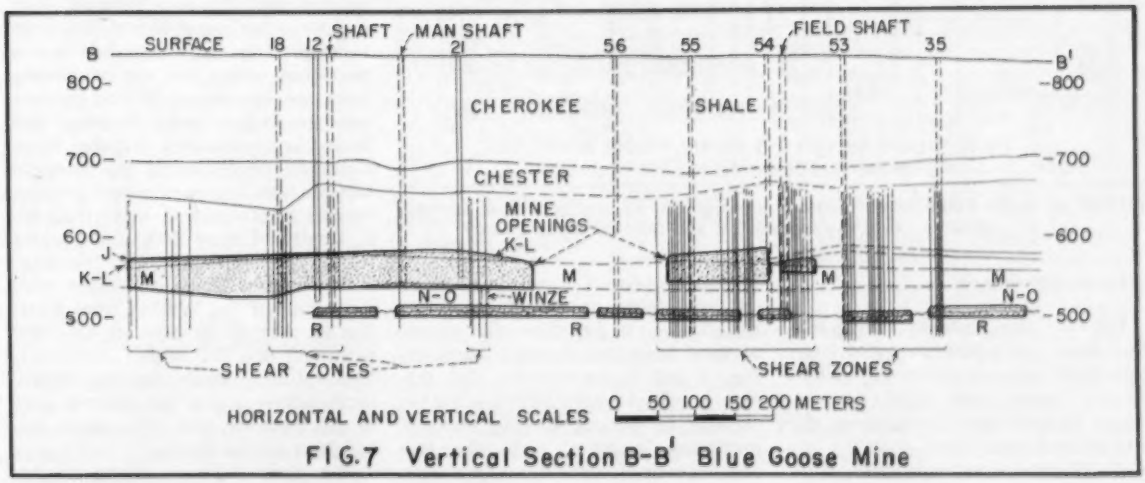


FIG. 7 Vertical Section B-B' Blue Goose Mine

Note the Following Details in These Drawings

In Fig. 3 and 4, the ore localized where changes in contour spacing indicate maximum flexing of beds. Note also concordance of orebodies with shearing. Widely-spaced contours are largely barren except in the structural trough in the northeast.

In Vertical Section A-A' (Fig. 5) the Chester is much thicker in the trough, than over mine workings. In Fig. 6, blanket orebodies localized in the disconformity separating the R from the N-O beds. See next page for the explanation.

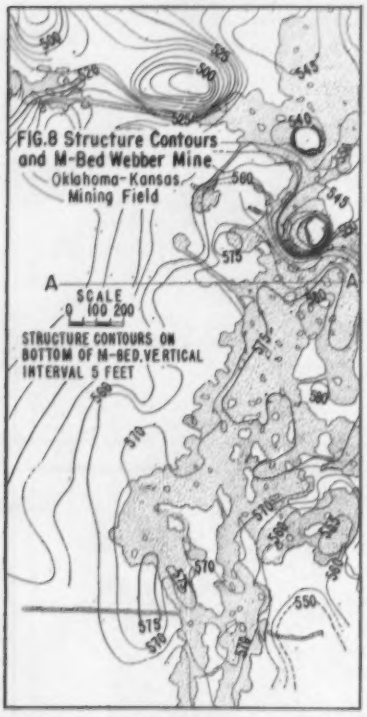
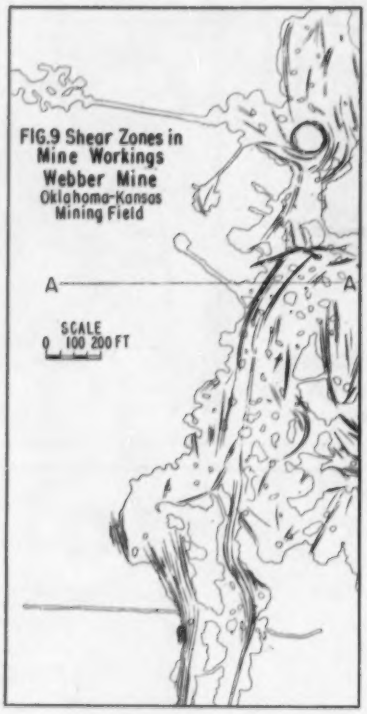


FIG.8 Structure Contours and M-Bed Webber Mine
Oklahoma-Kansas Mining Field
A
SCALE
0 100 200
STRUCTURE CONTOURS ON BOTTOM OF M-BED. VERTICAL INTERVAL 5 FEET



SHEARING AND FLEXING prepared beds for the deposition of dolomite and ore. The circular shear zone outlines a barren slump surrounded by ore.

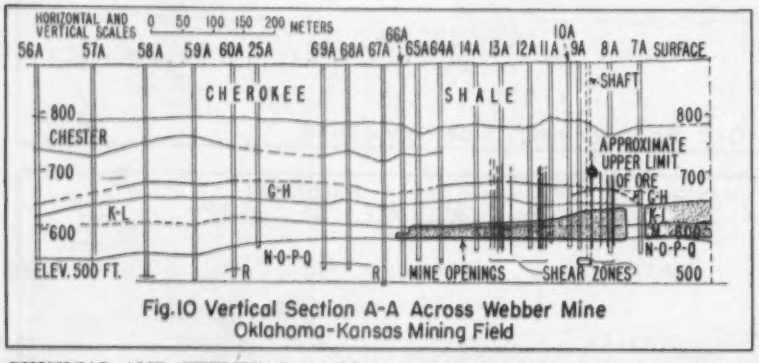


Fig.10 Vertical Section A-A Across Webber Mine
Oklahoma-Kansas Mining Field

PHYSICAL AND CHEMICAL condition prepared the ore-bearing beds as sponges for ore deposition. Ore was deposited in and near the shear zones.

(Continued from p 9)

Parts of the Tri-State mining district have many characteristics common to oil fields—anticlines, synclines, domes, basins, and allied flexures. These features are common in the Oklahoma-Kansas field.

To illustrate methods that were applied in defining and appraising ore deposits in nearly every mine in the Tri-State mining district, data pertaining to the Blue Goose and Webber mines are included here. (See Figs. 3 to 10, inclusive.)

The Blue Goose mine, about one mile southwest of Cardin, Okla., is on both flanks of the Miami shear trough, and it has been the source of very large ore deposits. Note on Fig. 3 and 4, respectively, that the ore localized principally where changes in contour spacing indicate maximum flexing of beds, also the concordance of orebodies with shearing. The areas of widely-spaced contours are largely barren, except in the northeast corner, where an orebody was developed in the structural trough.

The orebody in the terrace extending easterly and westerly from the main shaft was of the width shown in these workings and from 20 to 40 ft high. The orebody along the westerly flank of the Miami shear trough was from 10 to 100 ft high.

The vertical section across the Miami shear trough (Fig. 5) shows that the Chester is much thicker there than over the mine workings. Increased thicknesses of this formation are common in basins and similar depressions in the Oklahoma-Kansas field, as the pre-Chester deformation flexed and shattered the Boone, and the Chester was deposited on a much eroded Boone surface.

In the Blue Goose and contiguous mines to the southeast, blanket-like ore deposits about one square mile in extent and 5 to 15 ft in thickness localized along the disconformity that separates R bed (Reeds Spring) from the formations that overlie it. This is the so-called "sheet ground" ore. The strata directly above and below this ore bed are massive and about 50 ft in thickness and thus resisted internal deformation. Blanket ore deposits in the same horizon localized under similar conditions in an area about six miles square west of Baxter Springs, Kans. Some of these deposits cover many acres.

The Webber mine borders Treece, Kans., on the northeast; its ore and concentrate production per acre of mined area rank among the ten best in the Oklahoma-Kansas field. Physical and chemical conditions prepared large volumes of the Boone strata as sponges for the ore minerals. The major ore horizon is M bed, but large volumes of ore were deposited in and near shear zones that are continuous from the bottom of M bed upward into the higher beds. Shearing and flexing in combination prepared these strata for deposition of the dolomite and ore. Ore has been mined through vertical thicknesses of more than 60 ft, lengths of more than 1200 ft, and widths of more than 600 ft. (See Fig. 8, 9, and 10.) Some drill holes near the center of the Webber tract show that the formations there are but little deformed and are largely limestone. The Miami shear trough trends northeasterly across the western part of this property, and ore deposits are localized on its flanks.

The circular slumps shown on the structure contour map of the Webber mine (Fig. 8) represent conditions that occur in several widely scattered mines in the district. The slump in the northeast corner of this mine is approximately 100 ft in diameter and the partly chertified core dropped 22

ft in relation to strata bordering its perimeter. A doughnut-shaped orebody localized around the core in the circular shattering in M bed. One similar circular pattern in the St. Louis No. 4 mine in the eastern part of the Oklahoma-Kansas field shows that the core and the strata around it are at the same elevation, thus the slumpage in the Webber mine may be due to solution of certain strata by ground waters.

The partly chertified Boone formation reveals more than 15 interbedded massive and thin bedded units (competent and incompetent strata) which were necessary factors in localizing these ore reservoirs. These units range from several feet to 30 ft in thickness. The largest and most important orebodies localized where the strata were deformed by both flexing and shearing; some of these ore deposits range to 30 ft in height and 100 ft in width and many hundred feet in length. Approximately 60% of the ore mined was from such localizations in M bed. (See Fig. 2.) Ore deposits second in importance localized in shear zones that transect thick and thin strata through vertical distances of 25 to 150 ft and lengths to about one-fourth mile.

Third in importance are the ore deposits of the bedded type, from 5 to approximately 15 ft in vertical thickness and from a few square yards to more than one square mile in area. This bedded type of ore deposit is generally in or closely related to the serrated disconformity that separates the Reeds Spring from the younger formations. Drill holes, outcrops, and underground openings show that the disconformity extends over an area of several thousand square miles, is ore-bearing in a few localities, and was an important ore source in parts of the Oklahoma-Kansas field. Bedded ores also localized widely but in less volume in K, H, G, and E beds shown in the stratigraphic section (Fig. 2).

The Southeast Missouri District

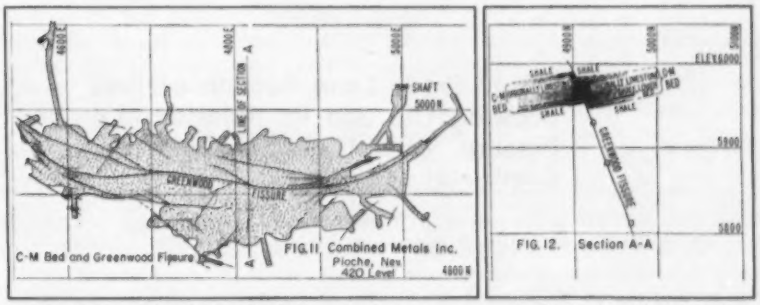
The Southeast Missouri mining district has been a major domestic source of lead for nearly 100 years. Its producing area approximates 400 square miles but a very large percentage of the total ore output, valued in excess of one billion dollars, came from a structural basin less than 30 square miles in area located between the Farmington anticline and the Simms Mountain fault.

Table II. Production of Southeast Missouri district, 1907-1953 inclusive

Complied from U. S. Geological Survey and U. S. Bureau of Mines Statistics

	Recoverable Metal Content (short tons)		Lead	Zinc
	Lead	Zinc	(percent)	
Production of Southeast (and Central) Missouri, 1907–1953, inclusive....	7,227,933	40,993*		
Production of the UNITED STATES, 1907–1953, inclusive**.....	21,635,880	26,153,689		
Percent of production from Southeast (and Central) Missouri, 1907–1953, inclusive.....			33.4	1.57

* Includes 2,144 tons from slag, etc.
** 1953 production figures for United States are preliminary.



THE GREENWOOD FISSURE is an important passageway through which abundant ore-bearing media gained access to ore reservoirs in the CM beds.

The patterns of the mine workings of the district (northeasterly and northwesterly trends) suggest deformation by northerly compression, the recognized condition in the Tri-State mining district and the Upper Mississippi Valley mining district. The ore localized in the sheared and otherwise deformed parts of the Bonneterre dolomite. This formation, about 400 ft thick, was originally limestone.

Upper Mississippi Valley Mining District

The Upper Mississippi Valley mining district, is several thousand square miles in area, and mining has been in progress there for more than 200 years. From 1820 to 1870 it was a major world source of lead, with estimated gross production exceeding 500,000 tons of metal. Later, zinc mining predominated and continued until about 1920 when operations were largely suspended until about 1940. Accurate production figures for the district are not obtainable.

The pattern formed by the district's mine workings indicates zones of adjustment which trend northwesterly, northeasterly, and easterly, such as would result from northerly compression. The larger ore deposits of the district are in these zones. Principal northwesterly trending zones are arranged en echelon and spaced several miles apart. They are from 4 to 6 mi long, and comprise 5 or more orebodies, more or less in line, ranging to approximately one-half mile in length. Single orebodies may contain 1-million tons of ore. Beds in these zones have been intensely flexed and sheared.

The Upper Mississippi Valley mining district is the source of about 2.0% of the current domestic zinc production, and its present lead production is negligible.

Southern Illinois-Western Kentucky District

This district, several hundred square miles in extent, has been the major source of fluorite for many years. During the past 15 years it has also become a source of considerable zinc with the discovery of large orebodies composed of fluorite, sphalerite, and a little galena, in the Cave-In-Rock area of Illinois and parts of western Kentucky.

All of the Illinois ore deposits are closely related to structural deformation. They localized in faults and shear zones in favorable strata in Mississippian limestone. Some faults and shear zones are several miles long, and vary in width from several feet to about 100 ft. The ore de-

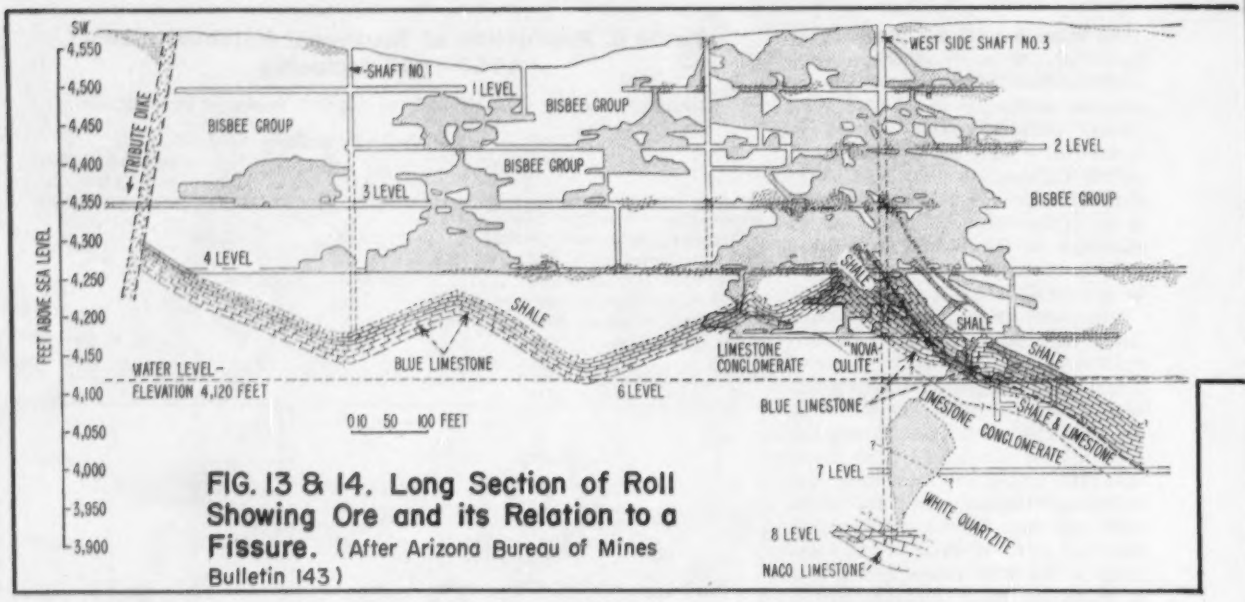


FIG. 13 & 14. Long Section of Roll Showing Ore and its Relation to a Fissure. (After Arizona Bureau of Mines Bulletin 143)

VEIN ORE SHOOTS in this part of the Tombstone, Ariz., district are localized along northeast fissures, particularly where fissures cross anticlinal rolls. Other ore shoots appear to localize where fissures slice through dikes.

posits occupy parts of these zones.

Most of the Kentucky ore deposits are associated with fissures and fissure zones. Deposits of sphalerite have also been found in tension zones between fissures about 100 ft apart.

Pioche, Nevada, District

The Pioche district was discovered more than 80 years ago and until about 1886, phenomenally rich oxidized silver-lead ore was mined from nearly vertical fissures in quartzite to water level, 1200 ft below the surface. Mining of sulphide ores commenced about 35 years ago and the district continues as an important source of lead and zinc. Oxidized manganese ores are also mined extensively.

The writers' knowledge regarding these ore deposits was gained years ago. Fig. 11 and 12 show conditions that were evident then as the Greenwood fissure is one of the important passageways through which abundant ore-bearing media gained access to the ore reservoirs in CM (Combined Metals) bed. The grade of this ore gradually decreases outward from the Greenwood fissure.

For many years the Combined Metals Reduction Co. management and its personnel have continued to prospect and develop ore deposits in the Pioche district and their work has solved many of its complicated problems.

As developed to date, the district is several hundred square miles in extent. The ore deposits localized in fissures, shear zones, and in bedded deposits in structurally prepared reservoirs in Cambrian sediments, through strata several thousand feet in thickness.

Structural deformation is widespread and intense in parts of the district, particularly in the Pioche Hills immediately west of Pioche, where the ore deposits localized almost exclusively in the CM limestone bed which is approximately 50 ft thick. Numerous mineralizing fissures intersected this bed and replaced parts of it with lead and zinc sulfides, and gold, silver, and manganese minerals. CM limestone is interbedded between thick shale members of the Cambrian formation, and the entire series was displaced and broken by numerous faults and fissures, some ore-bearing and some barren. These broken formations trend northwesterly in a trough-like channel one-half to one mile wide and more than two miles long in which CM bed is displaced more than 1200 ft vertically. Segments of CM bed range in area from fractions of an acre to many acres, and the ore deposits in it have similar characteristics.

Central District, New Mexico

Many features of this district are described in the literature. The ore deposits yield magnetic iron ore, copper, zinc, lead, and silver, and minor amounts of gold. Small satellitic districts yielded ores mined primarily for silver, for gold, or for manganiferous iron. Molybdenum is a by-product at the Chino copper mine.

Disseminated copper deposits at Santa Rita are in shattered intrusive rock and nearby altered sedimentary rock. This shattered area is in a mile-wide belt of northwest fracturing and faulting that crosses the dominant pattern of northeast faults and fractures. East-striking faults and fractures are particularly abundant near Santa Rita and strike toward the copper deposit from both sides.

Copper deposits north and west of Fierro N. M., are localized in shattered igneous and sedimentary rocks along the Barringer fault. The pyritic deposits contain chalcopyrite, secondary chalcocite, and quartz veinlets in sericitized and locally silicified host rock.

Zinc-lead-copper deposits and nearly lead-free zinc deposits replace Paleozoic limestone, or are in veins associated with faults that cut Cretaceous strata and enclosed quartz diorite sills. Vein ore shoots are localized where the fissured zone changes in strike and/or dip; some vein ore shoots are in fracture zones that rise steeply in the hanging wall of a strong fault.

Replacement zinc deposits are localized by shattering near the mar-

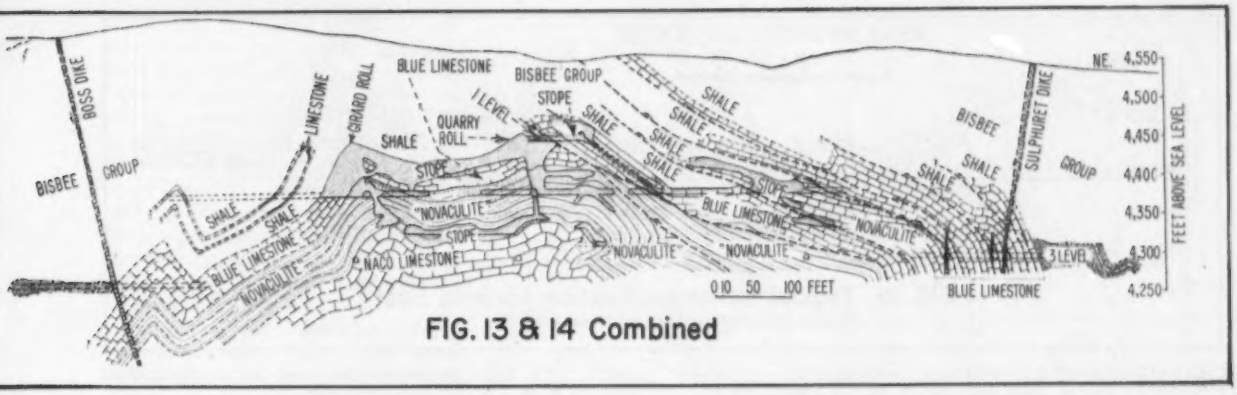


FIG. 13 & 14 Combined

gins of massive silicated zones around intrusives and by shattered and fissured rock commonly, but not invariably, along granodiorite dikes. These conditions have long been recognized in prospecting and developing the Central district ore deposits. In places, folds and warps of the bedding have been factors in localization.

The Groundhog mine illustrates the presence of ore under a later volcanic cover. The fault and dike zone, and a little ore, are exposed where the cover has been eroded, but much ore has been produced where the volcanic cover remains. The Groundhog fault underwent renewed movement after deposition of the post-ore volcanic rocks with some consequent displacement of those formations. Other faults in the volcanic rocks have smaller displacements, but some probably represent renewed movement on pre-ore structures in the older rocks.

Tombstone, Arizona

The bedded rocks at Tombstone include upper Paleozoic limestone overlain unconformably by Cretaceous shales and sandstones with some interbedded limestone in the lower part and limestone conglomerate locally at the base. The formations are folded along northwest axes and complexly faulted. Sheeted zones and minor faults strike northeast across the folds which plunge southeast at low angles and are crossed by strong faults downthrown to the southeast. Some folds are asymmetrical, the east flanks being the flatter. Minor thrust faults on the east flanks of some folds cause duplication of beds. Dikes that strike north-northeast cross the folds and intersect the northeast fissures in the formation.

Vein ore shoots are localized along northeast fissures, particularly where fissures cross anticlinal rolls. Other ore shoots appear to be localized where north-northeast and northeast fissures slice through dikes. Replacement ore shoots are localized in certain beds along the northwest rolls. They tend to favor the crests of rolls and the flatter northeast flanks of asymmetrical rolls. Most large replacement deposits are in the top beds of the Paleozoic limestone and the Blue limestone about 40 ft above. Other replacement deposits are in the "novaculite" under the Blue limestone and in 10-ft and 6-ft limestone beds above the Blue limestone.

The anticlinal rolls are divided into segments by the set of northeast fissures. Replacement ore along a roll may change horizon or end at a fissure intersection. A segment of a roll generally has a large orebody in only one horizon, though minor orebodies may exist at other horizons.

Some of the conditions described in the preceding paragraphs are illustrated in Fig. 13 and 14.

Exploration was directed along northeast fissures, north - northeast dikes, and northwest rolls, with due recognition of the stratigraphic factor in localization of replacement deposits.

Most of the ore of the district was oxidized. The mined ores were valuable mainly for silver, but important amounts of gold, lead, and copper were recovered. Production to the end of 1936 has been estimated at $37-million.

Taxco District, Guerrero, Mexico

Cretaceous limestone and overlying shale rest unconformably on metamorphic rock characterized by low-angle dip of the schistosity. The unconformity is characterized by locally steep topography and moderate relief. The Cretaceous shales are overlain by conglomerate and higher formations of volcanic origin.

The metamorphic rocks are intruded by dioritic dikes not known to intrude the Cretaceous rocks. Rhyolite dikes and plugs intrude the volcanic and older rocks, as do a few small intrusives of diabasic appearance.

Compressive forces thrust the massive Cretaceous limestone and overlying shale along the surface of the underlying schist. The rocks above the thrust are in broad, open, somewhat asymmetrical folds and domes whose axes are oriented roughly east and whose northwest flanks are more steep. The rock above the sole of the thrust zone is deformed and intensely sheared for thicknesses that range from a few feet to several hundred feet. The sole of the thrust is at or near the upper contact of the metamorphic rock on the crests and south flanks of buried hills and above that contact on the north flanks. Just southeast of Taxco, the basal Cretaceous limestone, here thin, was driven up to the southeast over Cretaceous shale along a counterthrust whose minimum dip-slip is 200 m. The schist below the sole is in places reduced to mylonite, and the schistosity deformed by small crinkled folds. These folds and a few low-angle shears in the metamorphic rock are apparently drag structures.

The rock formations are broken by normal faults, most of which strike northwesterly and dip at medium to high angles. Most of these faults are of pre-mineral origin, but some clearly underwent post-ore movement. Tight shears of northeasterly strike caused small displacement of northwest faults to the left. They lack veins so far as known, but a little sulphide in disturbed rock in their walls points to pre-ore age.

Some of the northwest faults cut both the metamorphic rocks and

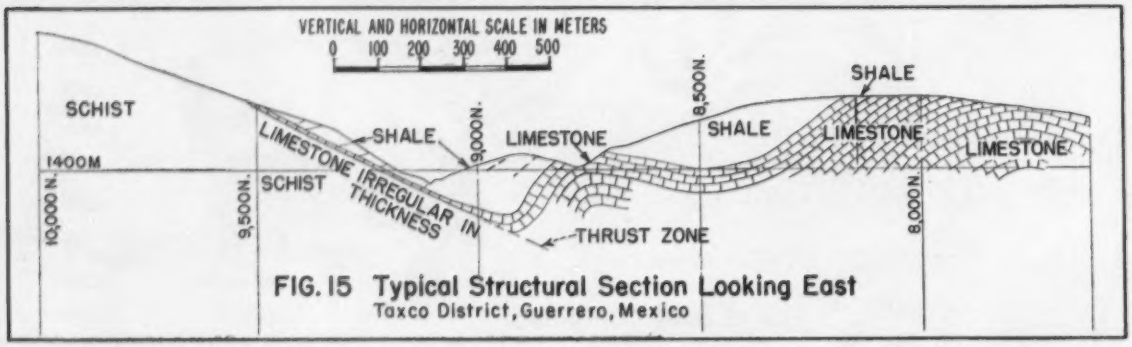


FIG. 15 Typical Structural Section Looking East
Taxco District, Guerrero, Mexico

CRETACEOUS LIMESTONE and overlying shale rest unconformably on metamorphic rock with low-angle schistocity. Compressive forces thrust the massive limestone and overlying shale along the surface of the underlying schist.

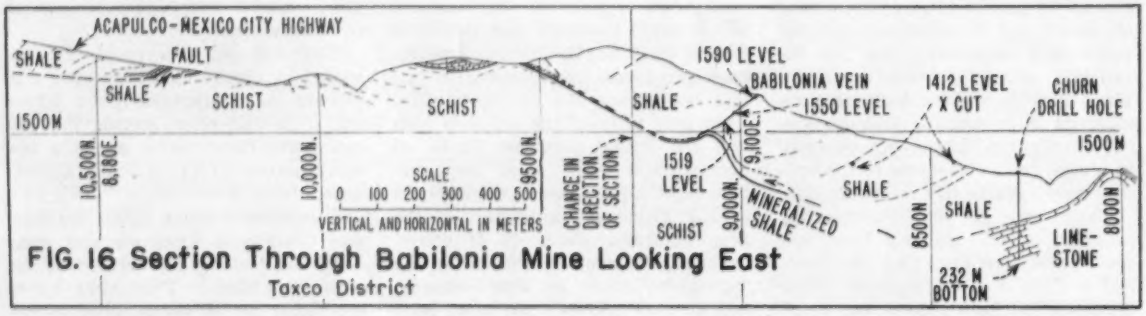


FIG. 16 Section Through Babilonia Mine Looking East
Taxco District

THE BABILONIA VEIN FAULT flattened into the sole of the thrust. Such vein faults appear to have originated by adjustment in the hanging wall of the thrust as the upper plate moved over buried hills in the erosion surface at the base of the Cretaceous.

Cretaceous formations. Others, such as the Babilonia vein-fault, are restricted so far as known to the Cretaceous rocks above the thrust. Some vein-faults that cut both metamorphic and Cretaceous rocks localiezd along diorite dikes in the metamorphic rocks.

Ore shoots have greater horizontal than vertical dimensions and diminish downward both in width and grade. The Babilonia vein-fault flattened into the sole of the thrust, and drilling failed to pick up any sign of extension below the thrust. Such vein-faults appear to have originated by adjustment in the hanging wall of the thrust as the upper plate moved over buried hills of the erosion surface at the base of the Cretaceous.

The zinc-lead-silver veins occupy faults of the northwest system, which range in strike from north to west-northwest. Minerals include quartz, sphalerite, galena, pyrite, and minor amounts of barite, fluorite, and specularite. Narrow veins of quartz and specularite and rare veinlets of barite cut the primary banding of zinc-lead sulphide ore. Wire silver, argentite and ruby silver were common in some of the base metal veins encountered there. Other veins which are mined for silver have quartz or carbonate gangue with very small amounts of base metal. Veins in limestone have carbonate minerals in the gangue.

Ore at the Babilonia mine is characterized by zinc predomination over lead, a little copper, 50 to 150g of silver per ton, and one gram or less of gold per ton.

A crushed shale mass in the thrust zone at the Babilonia mine is replaced by magnetite and hematite (25% iron), ilvaite, high-iron actinolite, and sparse sulphides of iron, zinc, and lead.

The shale walls of the Babilonia vein system are moderately to greatly silicified. This fact plus moderate to steep dip of the veins permitted shrinkage stoping.

The Babilonia area (Fig. 17) was selected for exploration after study of many veins distributed over an area of many square kilometers. Selection was based on structural pattern, known sulphides, and favorable features of leached outcrops. Veins were explored and exploited from adits because of their favorable relation to topography. All worthwhile ore was above the lowest or mill adit level.

At Juliantla, small replacement deposits in the top beds of the limestone are localized by rolls associated with miniature bedding thrusts.

Mina Azul, five kilometers east of Taxco, is a replacement fluorite deposit in Cretaceous limestone associated with a rhyolite plug. The rhyolite intrudes the fluorite deposit and contains xenoliths of fluorite cut by rhyolite stringers. It apparently utilized the same channelway along which the fluorite-depositing fluids rose, but at a later time.

Fig. 15 to 18, inclusive, show some of the conditions described in the Taxco district.

Structural Patterns and Ore Deposits

Plan maps that show the outlines of mines or mining fields may reveal important facts regarding them and their environment. Some such facts are evident in many mining regions.

In the Oklahoma-Kansas field, plan maps of the mined areas show numerous trends bearing northeasterly and northwesterly, and a few folds bearing easterly. These patterns infer structural deformation, with compression and shortening of the strata in

a general northerly direction and elongation in an easterly direction. Drill holes and underground observations abundantly confirm these conditions, which apply with equal emphasis to volumes of a few cubic yards to scores of thousands of cubic yards. Shear zones and other structural adjustments thus developed were the loci for the ore deposits. Shattering of marked intensity occurred contemporaneously in many parts of the Oklahoma-Kansas field.

In the Upper Mississippi Valley mining district, plan maps show mined trends similar to that of the Oklahoma-Kansas field, and the reasons for this pattern seem to be similar in both regions, which are about 600 miles apart.

In 1947 the existing pattern showed a missing segment in an important northwesterly-trending zone four miles north of Galena, Ill. A drilling program was initiated, ore was found in the fourth drill hole, and several important ore deposits were developed on this trend.

Ore Search Programs

The areas investigated range from fractions of a square mile to several hundred square miles; management, geologists, engineers, supervisors, and those who actually mined the ores cooperated to the fullest extent in these ore search and development programs. The factual evidence gained as the work progressed was appraised and, in many cases, immediately applied to the mining problems. Informal discussions, many of them at the working faces in the mines, materially helped in appraising the ore prospects and thus improved selective mining methods were more firmly established. The results were reflected in reduced operating costs and the knowledge gained was applied with success in many other mining properties.

Distinct relationships exist between pre-mineral structural deformation and ore deposits. Absence of deformations means barren formations. Even in mining environments, shear zones or flexures are generally ore bearing only within segments that were subjected to intensive deformation. Conditions for ore deposition vary in nearly every district and in some mines within them.

Ore deposits that show few if any surface manifestations could be very important sources of future ore production. Potential ore-bearing areas where these conditions are present are numerous and widespread. In many cases clues regarding these ore localizations may be gained by mapping the regional geology over and around them, particularly the structural environment.

Ore search programs are undertaken progressively and a general procedure is followed:

1. Summarize and digest all available information that may have a bearing on the region and its ore deposits.

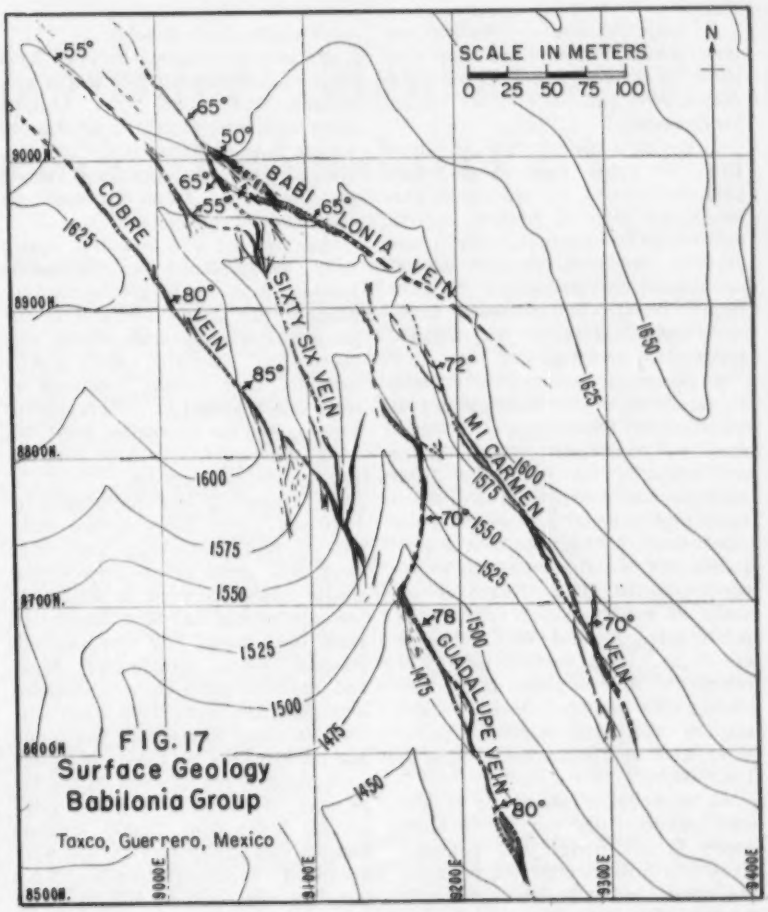


FIG. 17 Surface Geology Babilonia Group
Taxco, Guerrero, Mexico

THIS PART OF THE BABILONIA AREA was selected for exploitation because of the structural pattern, known sulphides, and favorable features of leached outcrops.

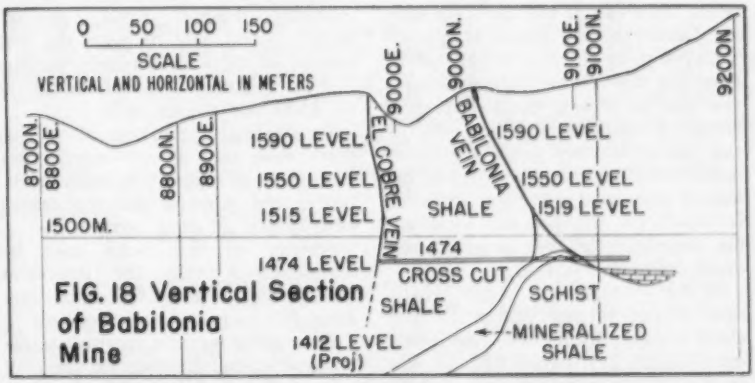


FIG. 18 Vertical Section of Babilonia Mine

VEINS WERE EXPLORED and exploited from adits because of their favorable relation to topography. All ore occurred above the lowest or mill adit.

2. Map and appraise surface and underground exposures as they may show the regional and local structural deformation and its influence on ore localizations.

3. Evaluate the information gained from the above steps to determine characteristics of the ore search problems, the areas of interest, and the methods to be used in defining the ore deposits. Applicable methods depend upon many factors, such as form of deposit, depth below surface or workings, inclination of the ore deposits, and surface topography.

4. Assemble base maps on which to record all of the essential factual evidence. If these maps are inadequate or unavailable, suitable maps are prepared or purchased from agencies that are equipped to produce them from original sources. In many cases aerial photographs are a very satisfactory medium on which to record essential data. Negatives on scales of 1:10,000 to 1:12,000, and prints enlarged to double that scale or larger, have served well. For reconnaissance purposes maps and photographs on much smaller scales may be used, such as contact prints at 1:20,000 and topographic maps at 1:62,500.

An appraisal of all of the factual data gained from the above steps points to the barren and potential areas in a project. Only the potential ore areas, generally less than one-third of the total, are given further consideration. Prospecting by drilling from the surface is generally a requisite for nearly horizontal ore deposits, as those of the Tri-State mining district and the Upper Mississippi Valley mining district. Nearly all of these ore deposits are hidden under a few feet to several hundred feet of barren formations. Drilling patterns and spaces between holes are determined from factors such as trends, extent of individual structural segments in which the ore deposits localized, the dimensions of ore deposits, and depth below the surface.

In the Tri-State and Upper Mississippi Valley mining districts, initial checkerboard drilling on one-fourth mile centers has served well. If any of these holes indicated ore possibilities, additional holes were completed to gain an answer. Initial drilling gave sufficient evidence on which to eliminate three-fourths or more of many large land tracts. In all cases drilling was done to obtain information regarding structural deformation. When a probable ore deposit was indicated, its merits were determined from additional drill holes.

Various geophysical methods have been used to improve ore search procedures and lessen costs. Drilling costs vary from $2,000 to $5,000 per square mile, but the results are conclusive. Less costly methods would greatly increase areas that could be economically prospected.

An area of one hundred square miles, centered in the Oklahoma-Kansas field, was adequately appraised with drill holes and underground operations and further surveyed by magnetic and gravity methods. One reading for each 40 acres was recorded in a checkerboard pattern, but the anomalies from this work apparently have little relationship to the ore deposits.

Soil sampling was undertaken in 1940-1941 over many square miles east of Joplin, Missouri. The initial work was done in an area several square miles in extent in which the ore localizations had been determined from drill holes. The two methods checked within satisfactory limits and the soil sampling was extended into undrilled areas. One small orebody of about 50,000 tons was found and the sampling indicated only small and scattered ore deposits in the remainder of the area that was prospected. More than 11,000 separate samples taken from residual soil were examined spectrographically. The sampling was done at 100 to 300-ft intervals and the depths ranged to 20 ft below the surface. The results were shown by contour maps based on the relative amounts of the several elements present. Lead, gallium, nickel, cobalt, and tin were the best indices in these determinations. The cost for this project varied from $200 to $500 per square mile.

Geophysical techniques of various types were used in ore search problems in Illinois, Wisconsin Kentucky, and Arizona and the results were helpful in some cases.

Spacing of drill holes must be commensurate with the structures that localize a large individual oreshoot or group of small oreshoots.

Area ratios must be determined between structural deformation and drill hole spacing, and these differ in nearly every mining district. In the preliminary drilling, at least one drill hole should penetrate each structural segment that may contain an ore deposit, and knowledge regarding spacing is gained by experimentation as the drilling progresses. If the deformation is more or less oval in outline, checkerboard pattern drilling is suitable. Elongated deformation, as in shear zones, may best be prospected by drill holes one hundred to several hundred feet apart across them, and similar crossing at one hundred to many hundred yard spacing along their length.

Isopach maps showing the thickness of the ore-bearing strata or other important features were used with success over many square miles in the Upper Mississippi Valley mining district. In that district the zones of structural deformation, in which the ore deposits localized, were leached in part by ground waters.

The adequate use and interpretation of structure contour maps have proved exceedingly helpful in solving many complex ore search problems. In some ore search investigations these maps were established with little effort and in others only after many months of work. Viewed in the three dimensions, the reasons for ore localizations or their absence in the bedded formations covered by the map unfolded as the prospecting and development work progressed. A third dimension could not be established in some mines, thus necessitating added work and expense for ore search.

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Cerro de Pasco Drillers' Manual Defines Exploration Procedures

THE DRILLING of a porphyry copper deposit requires utmost care and accuracy, but it must also be done economically. Standardization of drilling procedure is the most effective means of obtaining the correct end result.

The drill hole, whether churn or diamond drill, is, for all practical purposes, a sample. An accurate sample at a permissible cost is the primary objective. Speed of drilling is of importance in the cost of sampling, but is of secondary consideration in the overall objective.

Essential steps for obtaining accurate churn drill samples are these:

a. Casing must be carried as close as possible to bottom of the hole.

b. The sample must be bailed from the bottom of the hole as cleanly as possible until no appreciable quantity of cuttings is found. The same applies to cuttings from reaming operations.

c. Sample equipment at the drill rig must be thoroughly cleaned before finishing each sample.

d. Unintentional salting must be avoided at all points from the drill hole through the assay laboratory.

e. The sample drying process must be carefully controlled to prevent overheating and resulting loss of combined water and sulphur.

f. All records must be complete and accurate. Too much information is better than too little.

Essentials for obtaining accurate diamond drill samples are, in principle, the same as those for churn drilling. Those essentials peculiar to diamond drilling may be summarized as follows:

a. The primary objective is to obtain as high a core recovery as possible.

b. Accurate sludge sampling operations should be maintained at all times, even though core recovery is high.

c. All possible measures must be taken to ensure that at least 80% of the water used for drilling is returned to the surface, and that the tanks and equipment used to measure the water are properly maintained.

What Drilling Must Yield

When exploring a porphyry copper deposit by drilling, it is the aim to achieve greatest possible accuracy of sampling compatible with efficient work and at a cost that is economically permissible.

The following procedures, based on experience and long observation of such work, are recommended for the Cuajone deposit. Improvements of methods are of course, possible and the engineer in charge of an exploration campaign should always be on the alert for such improvements. However, before changes and amendments are made, extensive comparative tests made by others should be consulted. Before being put into regular use, such changes must have the approval of the supervisory and managerial staff.

Standardization, establishment and follow-up of a strict routine to be used from the start of the campaign will insure accuracy of the end results, and reduce operating expense.

Drilling and Casing

Churn drill holes are normally collared and drilled 13 in. dia through the surface wash and soft capping 12-¾ in. O.D. surface pipe is installed and drilling is continued with a 12-in. bit through the volcanic capping, leached capping and oxide ore until the enriched zone is reached, or until caving and protection of the oxide ore samples call for installation of 10-¾ in. O.D. casing before reaching the enriched zone.

The 10-¾ in. casing is then set at the top of the enriched zone and drilling continued. In the enriched zone the casing will be carried down with the drilling not more than 15 m from the bottom of the hole, either by straight reaming or underreaming. Under normal conditions at Cuajone, in which the enriched zone is of substantial thickness and of considerably higher grade than primary ore, the casing will be set at the bottom of the enriched zone, and will remain in place until the hole is completed. In case the enriched zone proves to be relatively thin and low grade, the casing may be run to depths below the enriched zone.

The primary ore zone will then be drilled and cased as dictated by the condition of the hole walls in order to minimize salting of samples and to protect the tools, in accordance with the judgment of the project superintendent. When it is determined that a column of 15 m of protore (copper content below assumed cut-off grade) has been cut, the hole will normally be cased to the top of the protore before proceeding with the drilling, unless in the opinion of the superintendent the condition of the ground and location of casing previously set in the ore above does not warrant such practice.

Sampling at the Drill Rig

Whenever drilling water has to be put into the hole, the driller must lower the water to the bottom of the hole in the bailer, to avoid washing the sides of the hole. Standard short dart-valve bailers or flat-valve bailers are used to remove the sludge from the hole at the established sampling interval. Choice of the bailer will depend on drilling and sludge conditions encountered. If cuttings are difficult to pick up with the bailer, and salting of samples occurs from higher sections already drilled, flat-valve

The Authors

The Manual in its present form represents the combined efforts of the following:

H. A. Kursell, consulting mining engineer, was author of the major part of the Manual; also F. N. Spencer Jr., resident mining engineer; R. S. Bemis, general superintendent of mining; W. C. Lacy, chief geologist; G. T. Vandel, general superintendent of concentrating; T. McPardee, superintendent of the Cuajone Development Project; A. Davidson, assistant project superintendent; J. D. Hamilton, geologist of the project, and M. de Losada, ore dressing technician.

GEOLOGIC LOG
Cerro de Pasco Corporation

Churn Drill Hole No. _____ File No. _____
Total Depth of Hole _____ Property _____ Date _____
Log By _____

Depth of Sample	Copper Assay		Rock Classification	MINERALIZATION			Alteration	HEAVY MINERALS IN CONCENTRATES	REMARKS
	Total	Non-Sul		OXIDE	SULPHIDE	SILICIF.			

COMPOSITE CHURN DRILL LOG
Cerro de Pasco Corporation

Property _____ Area: _____ File No. _____
Collar - Grid Coordinates N. _____ E. _____ CHURN DRILL Hole No. _____
Collar Elevation _____ m: Scale 1 cm. = 4/m. Logged by: _____ Date Started: _____
Depth of Hole _____ m. No. of Sheets, this log _____ Drawn by: _____ Date Finished: _____
Water Level _____ m. EXPLANATION Date: _____ No. of 8 Hour Shifts _____

Ore	Rocks		Mineralization		Alteration	Hardness
O = Oxide Ore E = Enriched Sulphide S = Primary Sulphide P = Protore	t = Talus Overburden v = Post Mineral Volcanics c = Leached Capping mp = Monzonite Porphyry qmp = Quartz Monzonite Porphyry	di = Diorite bt = Basalt rp = Rhyolite Porphyry bx = Breccia	cry = Chrysocolla cu = Native Copper li = Limonite cc = Chalcocite bn = Bornite py = Pyrite	sl = Sphalerite mo = Molybdenite cp = Chalcopyrite	St = Strong F = Fair W = Weak	H = Hard M = Medium So = Soft

Elevation	Depth	Copper Assays: Cuajone Total	Cuajone Non Sulphide	Cuajone Average	Oroya Total	Oroya Non Sulphide	Oroya Average	Composite Check Assays	Classifications: Ore	Classifications: Rocks	Mineralization	Alteration	Hardness	Dryweight of Split Sample Kgs.	% Over or Under Theoretical Weight	Casing: Hole Drilled	Casing: Hole Reamed	Casing: Hole Cased	Remarks	Copper Assay Graph: - .5	- 1.0	%Cu - 1.5	- 2.0	- 2.5	- 3.0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21					

bailers or darts shorter than standard length may be used to clean the hole properly. The driller should bail the hole until the sludge is removed as completely as possible, and until no appreciable quantity of cuttings remain in the hole. When bailing from under water, the driller must bail until no appreciable quantity of cuttings is visible when the bailer is dumped. Normally three to four runs with the bailer are necessary to clean the hole since the drillers are required to run a bailer 1 in. smaller in dia than the hole size. This practice reduces the number of necessary bailer runs.

Sludge is discharged from the bailer into a large steel dump box with splash guards, and conveyed to a 3 or 4-tier (dependent upon sample interval) cascade Jones type splitter with a swinging baffle and splash guards which improve the eveness of distribution of the sample over the tiers of the splitter. The steel launder which conducts the sludge from dump box to the cascade splitter is designed to reduce flow surges to a minimum. The dump box, launders and splitter are set up so that the grade of the launder is sufficient to prevent settlement and segregation of the sludge. A hoe having a blade the same width as the launder is furnished to the drill rig sampler who uses the hoe to scrape down thick sludge or any material which may have settled.

The sample split from the cascade splitter is caught in a square, straight-sided metal tub.

Reduction of the samples by splitting in the cascade splitter is to ⅛ size. Further reductions may be made by splitting by hand in a Jones sample

splitter to split limits as follows, if further sample reduction is necessary. Splits are based on sample interval of 2 m:

12-in. dia hole 1/32
10-in. dia hole 1/32
8-in. dia hole 1/16
6-in. dia hole 1/8

Pressure water through a ½-in. rubber hose must be available at the drill to clean the dump box launder and Jones splitter after bailing is completed and before the taking of a sample is ended. Approximately 20 liters of sludge are placed in a clean, covered milk can sent to the sample preparation room with an attached metal tag, giving hole number, sample number and depth of hole where sample was taken.

The setting up of the sampling equipment and the sampling is supervised by a trained sampler. A sufficient number of samplers must be available to give close supervision to each drill shift. The sample interval to be used at Cuajone is 2 m.

Contents of cans containing samples received from the drill rig may be passed over a pressure filter if sufficient steam-plate drying capacity cannot conveniently be provided. Filter size should be sufficient to accommodate the total sample without splitting, and cake from the filter passed directly to the steam dryer.

Steam Drying Is Superior

The steam dryer now used at Cuajone, which is believed to be superior to the sand bath type, is oil-fired and produces steam at low pressure under a hot plate. The steam container is equipped with an adjustable pressure release valve which can be set for a pressure equivalent to 105 deg C at the altitude concerned. It should also be equipped with a thermometer so that the actual temperature may be checked. Such a design ensures a temperature low enough to prevent the driving off of combined water and burning of sulphur.

Pressure water through a ¾-in. hose fitted with a pipe nozzle having a 10-in. piece of rubber tubing at the end will be provided at the hot plates, and each can containing the drill sample will be carefully dumped, then thoroughly washed onto the hot plate so as to assure the removal of all material from the can. When the sample has dried, it will be removed, and the plate cleaned with a wire brush.

Between samples the hot plate must be washed to remove any caked slimes left from the previous sample.

CHURN DRILL SHIFT REPORT
Cerro de Pasco Corporation

File No. _____

Property _____

Hole No. _____ Date _____ 19___
Drill No. _____ Shift _____
Bit Type _____ Driller _____
Casing Lowered - Size - From - To Helper _____
_____ Meters Water - Depth Encountered _____ Meters
_____ Meters
Bit Used _____ Meters
_____ Meters

EMPLOYMENT OF TIME

Moving and Setting Up _____ Repairing Engine or Rig _____
Drilling and Bailing _____ Cementing Hole _____ From ___ To ___
Setting Casing _____ Fishing _____
Removing Casing _____ Reaming Hole _____ From ___ To ___
Equipment Repair _____ Cleaning Hole _____ From ___ To ___
Other Delays _____

SAMPLES

Depth From	Depth To	Color of Sludge	Condition of Hole (Caving etc.)	Hardness of Rock V H – Very Hard H – Hard M – Medium S – Soft V S – Very Soft	Is Sample Reliable etc.	Size To Which Sample Was Cut (Number of Splits)	Number of Bailers	Dry Weight of Split Sample	Remarks (Note Thickness of Extremely Soft Areas) (Specify Dry Weight of Aqua-Gel Added)

GENERAL REMARKS

Depth of Hole at Beginning of Shift _____ Meters Samples Left in Tubs _____
Depth of Hole at End of Shift _____ Meters Samples Canned _____
Sampler _____

The dried sample is weighed and the weight recorded. The entire sample is first passed through a jaw crusher to break up lumps and then through a roll-crusher to reduce all material to minus 10-mesh (1.651 mm). The minus 10-mesh sample is then mixed by rolling on a 6-ft square rubber cloth. The sample is next passed through a 10x8-in. (¾-in. opening) Jones riffle to yield a fraction weighing at least 2500 g. About 500 g of the Jones riffle reject is also cut out to be stored in suitably-marked, hermetically-sealed, quart-size glass jars. The 2500-g sample is passed through a Braun pulverizer, and the ground sample passed over a 100-mesh screen. Any plus 100-mesh material is reduced further in the pulverizer or on a bucking board to minus 100-mesh and added back to the main bulk of the sample. The sample (now about 2500 g of minus 100-mesh material) is next rolled on a 2-ft square rubber cloth for thorough mixing and then quartered to produce four parts. These four samples are then packaged for assaying or filing. One of the pulps may be split into two parts for filing purposes.

A galvanized washtub of 15 or 20 gal capacity is placed at the sample reject discharge of the cascade sampler. Cuttings caught in the tub will provide geological and sludge board samples in case the original sample is spilled or lost.

(*Please turn page*)

GEOLOGIC LOG
Cerro de Pasco Corporation

Diamond Drill Hole No. _____ File No. _____
Total Depth of Hole _____ Property _____ Date _____
Log By _____

Depth From	Depth To	Rock Classification	MINERALIZATION OXIDE	MINERALIZATION SULPHIDE	MINERALIZATION Silicif.	Alteration	HEAVY MINERALS IN CONCENTRATES	REMARKS

COMPOSITE DIAMOND DRILL LOG
Cerro de Pasco Corporation

Property: _____ Area: _____ File No. _____
Collar - Grid Coordinates N. _____ E. _____ D. Drill Hole No. _____
Collar Elevation _____ m. Scale 1 cm. = 4/m. Logged by: _____ Date Started: _____
Depth of Hole _____ m. Bearing _____ No. of Sheets, this log _____ Drawn by: _____ Date Finished: _____
Water Level _____ m. Inclination _____ EXPLANATION Date: _____ No. of 8 Hour Shifts: _____

Ore	Rocks		Mineralization		Alteration	Hardness
O = Oxide Ore	t = Talus, Overburden	di = Diorite	cry = Chrysocolla	sl = Sphalerite	St = Strong	H = Hard
E = Enriched Sulphide	v = Post Mineral Volcanics	bt = Basalt	cu = Native Copper	mo = Molybdenite	F = Fair	M = Medium
S = Primary Sulphide	c = Leached Capping	rp = Rhyolite Porphyry	li = Limonite	cp = Chalcopyrite	W = Weak	So = Soft
P = Protore	mp = Monzonite Porphyry	bx : Breccia	cc = Chalcocite			
	qmp = Quartz Monzonite Porphyry		bn = Bornite			
			py = Pyrite			

Elevation	Sample Depth Recalculated to Every 2m. intervals	Final Copper Assay From Assay Log Recalc. for 2m. Sample Interv. Total	Non Sulphide	Average	Composite Assays	Classification Ore	Rocks	Mineralization	Alteration	Hardness	% Recovery Core	Total	Casing Hole Drilled	Hole Reamed	Hole Cased	Bit Size	Remarks	Copper Assay Graph (- .5 / - 1.0 / - 1.5 / - 2.0 / - 2.5 / - 3.0 % Cu)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Assaying

A 2-½-g sample is used for assaying. Each sample is assayed for total copper and non-sulphide copper content. The standard iodide method is used for the total copper determinations and the sulphur dioxide method for the non-sulphide copper determinations. Determinations are carried to the third decimal. Until such time that checks within 2% of contained copper are obtained with Oroya (where also electrolytic check determinations should be made from time to time), every sample in ore will be checked. Later it will be adequate to check in Oroya every fifth sample (10 m) of better grade ore, every tenth sample (20 m) of medium grade ore and every twentieth sample of material less than the assumed cut off.

Samples from non-commercial low-grade runs in protore or waste may be combined for longer columns up to 30 m. Precious metal content and molybdenum should be determined only for the composite samples in Oroya. Spectographic analyses should be made from time to time, on not more than one composite for each hole, for Pb, Zn, W, Mo, Bi, Se, Te, Ge, and whatever other determinations are normally made at Oroya.

Churn Drill Records

(1) A form of a suitable report is attached (see p 21).

(2) The form of the geologic log attached (see top p 20), is prepared for recording megascopic and microscopic examination of the samples. The microscopic examination of the samples is made with a binocular

DIAMOND DRILL ASSAY LOG
Cerro de Pasco Corporation

Property: CUAJONE

File No. _____
D. Drill Hole No. _____
Date: _____

Depth				Core			Combined Core 2 Met. Run		Sludge 2 Met. Run			Recovery %		Average For 2 Meter Run							Oxide Co. Assay			Remarks
																Adjusted Assays								
From	To	Hole Size	Sp. Grav.	Wgt.	Cuajone Assay	Oroya Assay	Wgt.	Assay	Wgt.	Cuajone Assay	Oroya Assay	Core	Sludge	From	To	Wgt.	Core	Wgt.	Sludge	Final Comb. Assay	Core	Sludge	Comb.	

microscope. All the minerals indentified and their relative amounts are recorded on a log, also the rock formation penetrated.

(3) The composite log for each completed drill hole forms the permanent record and is a condensation of all useful information pertaining to the hole. This log is compiled from the daily shift reports, geologic and assay logs.

(4) The sludge board is prepared from a part of the divided sample by a suitable trained workman. A description of the board follows:

The sludge or sample board affords at a glance a detailed picture of results obtained in the drill hole. The board is 1.60 m long, 0.12 m wide, and 0.01 m thick. It is made of seasoned lumber (Grade A), or its equivalent, has a hole at the top for filing in the sludgeboard rack, and is painted white.

The sample (200 g) is washed free of slime and a small portion of the larger rock fragments are saved. The rest of the sample is then panned till a concentrate is formed. Rock fragments and panned concentrates are dried and glued on the board opposite the sample interval marked in black India ink on the left side of the board. An allowance of 1 cm for each sample is made vertically and 5 cm for the coarse fragments and 3 cm for the concentrates horizontally. Coarse fragments are glued on the left side and concentrates adjoining them to the right. The assay value of each sample is recorded to the right of the concentrates. Each band of 1 cm represents a 2 m sampling interval. The hole number, its coordinates and elevation of the collar of the hole are recorded at the top of the sludge board. Should a hole exceed 150 m in depth, two or more sludge boards represent one hole.

(*Please turn page*)

DIAMOND DRILL SHIFT REPORT
Cerro de Pasco Corporation

File No. _____

Property _____

Hole No. _____ Date _____ 19____
Drill No. _____ Shift _____
Size of Bit - Number - From - To - Accuml. Total Driller _____
_____ Helper _____
_____ Water - Depth Encountered _____ Feet
Casing Lowered - Size - From - To Lost - Water At _____ Feet
_____ Feet _____
Casing Removed _____ Feet

EMPLOYMENT OF TIME

Moving and Setting Up _____ Cement Used - Type _____ Quantity _____
Drilling _____ Drilling Cement - From _____ To _____
Setting Casing _____ Cementing Hole - From _____ To _____
Equipment Repair _____ Drilling Mud - From _____ To _____
Other Delays _____ Reaming Hole - From _____ To _____

SAMPLES

Depth		Recoveries			Hardness of Rock V.H. Very Hard H-Hard M-Medium S-Soft V.S. Very Soft	Condition of Hole	Color of Sludge	Dry Weight		Sp. Gr.	Remarks
From	To	% Core	% Sludge	% Water				Core	Sludge	Core	

GENERAL REMARKS

Depth of Hole at Beginning of Shift _____ Samples Left in Sludge Box _____
Depth of Hole at End of Shift _____ Samples Canned _____
Total Loads of Water Hauled During Shift ____ Sampler _____
Water on Hand _____ Gallons

REPORTS FORMS appearing on this and preceding pages were designed to assemble vital exploration and geologic information obtained by churn drilling and diamond drilling at Cerro de Pasco's Cuajone project in southern Peru.

Diamond Drilling

Powerful diamond drills, capable of drilling a "BX" size hole to 2,000 ft depth, are required if diamond drills are to be used at Cuajone. Drill derricks should be quickly dismountable, lightweight, (aluminum pipe), strong, and of sufficient height to pull at least 40 ft of rods.

Drilling Procedure

NX (3-in. hole dia, 2⅛-in. core) BX (2⅜-in. hole dia, 1⅝-in. core), AX (1⁹⁄₁₆-in. hole dia, 1⅛-in. core) and eventually EX (1½-in. hole dia, 1⁵⁄₁₆-in. core) bit sizes will be used with non-rotating, self sealing double-tube core barrels. Casing of the holes is essential and the casing should follow the drill closely (within 10 m). The casing is lowered after reaming the hole, and underreaming should not be relied upon or attempted. Drilling with non-rotating double-tube barrels is slow and requires frequent pulls. Should ordinary double-tube core barrels be used, sludge samples become of increasing importance. The greatest emphasis is placed on the necessity to return at least 80% to 85% of the water used for a run. Therefore, adequate tanks with the necessary measuring scales should be provided so that the driller may know at all times how much water he has pumped into the hole during a run, and how much sludge has actually been returned. No return water must be taken for drilling from the overflow of a sludge-catching device before a run is completed. Adequate tanks and a proper set up must be available. If necessary an additional pump must be provided. There are many sludge-catching devices used in diamond drilling. Of the several devices tried, a cylindrical tank, 1.6 m high, 1.22 m dia with a conical bottom and a spigot in the bottom to draw off the sludge, have been proved to be satisfactory. Two such tanks can be provided for each drill for alternate 2 m runs. The clear water is syphoned off into a reserve tank and at the same time the sludge and wash water are caught in a 10-gal milk can and sent to the sample room. Here the sample undergoes the same treatment as the churn drill samples, with the exception that samples are cut only for assaying and composite assays.

Core and Sludge Sampling

Core recovered in drilling is carefully placed into core boxes with markers of hole depth, which are locked and sent to the sample room. Cores for each run as pulled are dried and weighed to establish core recovery. Only a small specimen from each run to indicate the nature of the rock penetrated and for microscopic studies, etc., is kept as a geological sample and stored in a suitable core box. The balance of the core is crushed and split on a Jones splitter. One part of the crushed core is stored in glass jars with hermetical metal seals, for reference, metallurgical tests, specific gravity determination, etc. The balance of the core is pulverized for assaying, check assaying, and composite samples. Core weight and assays of the several runs as pulled are first combined for one 2 m run, corresponding to the 2 m sludge run and core, and sludge samples for a 2 m run are then combined in proportion of the weight of the core actually recovered to the theoretical weight of the sludge, adjusted for sludge recovery. Overage is deducted from 100% to establish percentage of sludge recovery.

The adjusted assay for a 2-m interval drilled equals actual weight of core × core assay plus theoretical weight of sludge × sludge recovery × sludge assay, divided by actual weight of core plus theoretical weight of sludge × sludge recovery. For example, if the actual weight of core is X and the core assay is 1.25% Cu, the theoretical weight of sludge is Y, sludge recovery 80%, and sludge assay 1.33% Cu, then the equation would look as follows:

$$\frac{X \times 1.25 + Y \times .80 \times 1.33}{X + Y \times .80}$$

In practice it has been found that sludge actually recovered under most perfect running conditions may vary from 80% to 120% of calculated sludge.

Assaying

Assaying of diamond drill cores and sludge samples does not differ from assaying churn drill hole samples as previously described.

Surveying

Deep diamond drill holes should be surveyed for deflection and the results recorded in the shift reports and composite drill holes log under "Remarks." A Maas compass and glass tube of suitable composition for etching with hydrofluoric acid is sufficiently accurate for holes up to 300 m in depth. Diameter of the tubes will be the maximum commensurate with the diameter of the part of hole being surveyed.

Keeping of Diamond Drill Records

(1) The attached diamond drill shift reports are a more or less standard form. (See p 23.) Depths of holes are measured in feet and decimals, and later converted by the engineer compiling the composite drill hole log into meters, as it is not practicable to change the habits of American diamond drillers.

(2) The geologic log (see top p 22) is based on examination of the core megascopically and if need be, microscopically. All minerals recognized are recorded, as also the nature of the rock penetrated and any other observations obtainable from core study.

(3) The assay log (see p 23) contains all individual assays of short lengths of core obtained from several runs, usually required to drill the standard 2 m intervals and combines the results of core assays and sludge assays into final figures to be used for the permanent record.

(4) The composite log of the completed drill hole (see p 22) combines all pertinent information on the hole as a permanent record. It is compiled from shift reports, the geologic and assay logs.

Storage of Core Specimens

Each specimen of diamond drill core retained from every 2-m run is to be spotted with white paint and labeled with hole number and depth represented. Specimens are then to be placed in a heavy manila sample envelope (10.5 cm x 18 cm) with metal closing tab, labeled as follows:

CERRO de PASCO CORP.
Diamond Drill Core
Hole .....
..... feet to ..... feet
.....meters to .....meters

Specimens in the labeled envelopes are placed in open boxes, fabricated of construction lumber with inside dimensions 11.5 cm wide x 84 cm long x 12.5 cm deep. Each box will hold about 50 specimens. The boxes should be labeled on the ends as to hole number and depth, and placed in a rack constructed so that any box may be removed independently.

Editor's Note: In addition to the foregoing information, the Cerro de Pasco Drillers' Manual contains instructions pertaining to: The point at which to stop a wildcat drill hole; mapping and engineering drill grids, standards, scales, sections; details to be included in regular monthly progress reports; interpretation of results.

The Role of Geophysical Methods In Modern Exploration Programs

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I. Introduction

WE, IN MINING, frequently wonder why geophysical methods, particularly seismic, have been so singularly successful as to return oil in 1 out of 5 holes drilled, even to depths of several thousand feet, while mining geophysical approaches have continued to be relatively uncertain, incapable generally of detection below a few hundred feet of depth, or of diagnosis as to nature or concentration of mineralization.

A list of mining geophysical methods are:

Self Potential	Geothermal
Resistivity	Gravitational
Electromagnetic	Magnetic
Radioactive	Seismic
Geochemical	

We wish briefly to discuss these methods and their limitations, to indicate new developments and suggest the future.

For all these methods, except the seismic, the response recorded varies in some manner inversely with the distance away from the body or condition causing the anomaly.

In general we may write:

Response R is proportional

$$(P_2 - P_1) \iiint \frac{dv}{r^n}$$

where $(P_2 - P_1)$ is the physical property difference between the volume causing the anomaly and its surroundings, and $\frac{dv}{r^n}$ is a portion of the volume at distance r from the point of observation.

n is some integral power that varies with the method used, the factor measured and the shape of the anomalous volume—

Certain aspects are immediately clear.

(1) Unless a physical property difference is present, no anomaly results. Thus there may well be geological differences without physical property differences. For example, in two copper-bearing areas, Jerome and Southern Peru, there is little magnetic contrast between flows, porphyries and diorites so that these formations cannot be differentiated magnetically.

At Bisbee, the porphyry and limestones are essentially the same density, but this is useful as the only density contrast is then with the massive sulphides which may thus be sought gravitationally (or with the solution caverns in the limestone: and underground, a dense body below you is the same as a cavern above).

(2) The response varies inversely as the distance to the causative body. Thus, for a given volume, the nearer the cause, the much stronger the anomaly. Hence beware of surface material and features. The soil and drift cover usually has contrasting physical properties from the rock below and the air above. Hence anomalies may readily result from changes in the thickness or nature of the cover and from topographic features. This statement applies to most methods and necessitates either satisfactory corrections or limits the use of the method geographically. This will be apparent in what follows.

(3) The response varies with the volume and shape of the contrasting body. For a given breadth or thickness of the zone causing the anomaly, the response will be greater for a dike or manto, than for a cylinder or pencil, than for a sphere or lens.

Actually a volume can be expressed as some linear dimension cubed, so that the response involves the ratio of said linear dimension to distance from the station. Thus the response from a 1,000-ft wide tabular zone under 1,000 ft of cover is about the same as from a 10-ft wide similar zone under 10 ft of cover.

For a given size and shape of body, the response decreases rapidly with distance away and provides the serious limitation of all mining geophysical methods in detecting to depth.

For most conditions a lens-shaped body cannot be detected farther away than its diameter, a pencil farther than twice its diameter and a dike or manto farther than 10 times its width or thickness. These estimates are actually a bit hopeful.

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O'okiep Copper Co.
Tsumeb Corp.
Aero Service Corp.
Aeromagnetic Surveys
Newmont Exploration Ltd.

for items of information included.

II. Discussion of Methods in Use

The methods now will be discussed in the order previously listed.

Self Potential. The self potential method responds to sulphides undergoing oxidation. It does not respond to sulphides not undergoing oxidation such as sulphides below the water table. Topographic ridges, particularly if outcrop, or thinly covered, will give anomalies similar to sulphides. (Fig. 1.) A good conducting dipping strata or zone bounded by poorer conductors will also give a characteristic negative anomaly. (Fig. 2.) The former is due to local atmospheric electrical potential variations at relatively poor conducting surface ridges; the second is due to potential differences arising from horizontally flowing telluric or ground currents.

The self potential method is also seriously limited for work to depth since essentially only the oxidizing portion of the sulphides are effective, thus limiting the volume contribution to the response.

Nevertheless if the anomaly can be recognized as due to sulphides, the method can be said to be direct in evincing mineralization, even if scattered. Absence of anomaly does not eliminate sulphides and spurious sulphide-appearing anomalies may result as mentioned above. An example of a successful use of the method is S. F. Kelley's contribution to the Noranda C orebody discovery. Recent Phelps Dodge work at Tyrone has also been helpful.

Resistivity. The crux to the re-

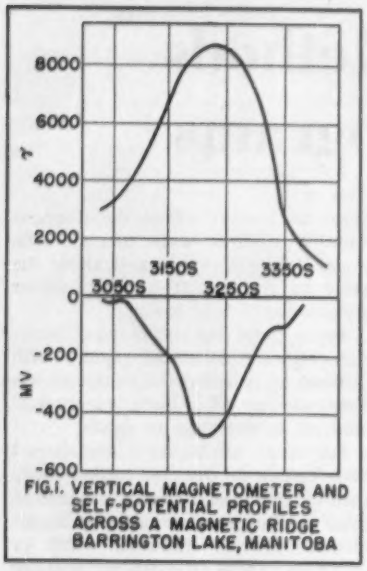

FIG.1. VERTICAL MAGNETOMETER AND SELF-POTENTIAL PROFILES ACROSS A MAGNETIC RIDGE BARRINGTON LAKE, MANITOBA

FIG. 1. Topographic ridges often give anomalies similar to sulphides.

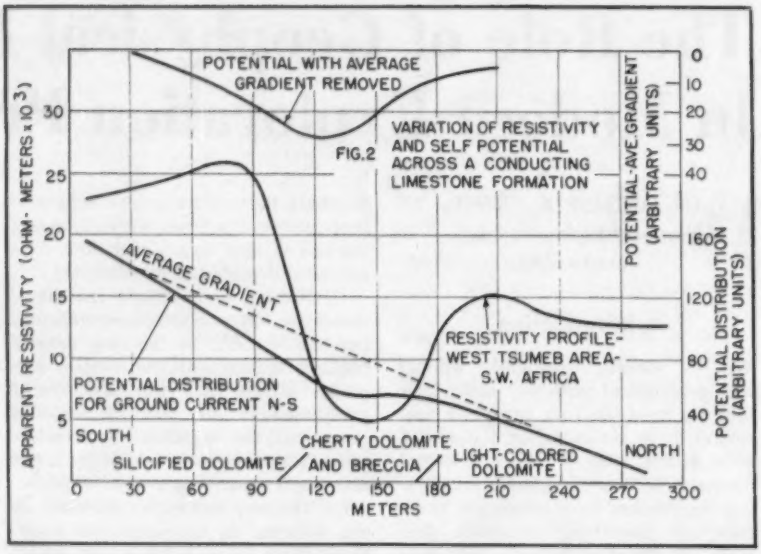

FIG. 2. A good conducting dipping strata bounded by poorer conductors will also give a characteristic negative anomaly.

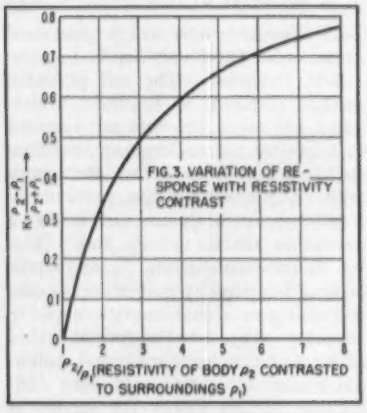

FIG. 3. Note that small resistivity contrasts cause relatively large anomalies.

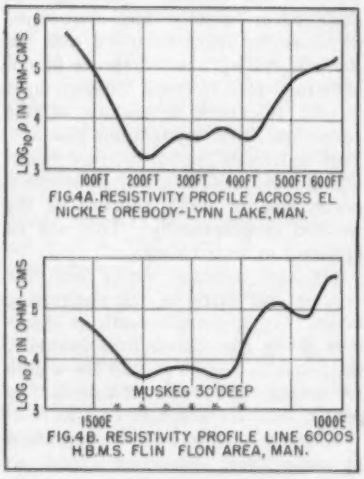
LOG10 ρ IN OHM-CMS
100FT 200FT 300FT 400FT 500FT 600FT
FIG.4A. RESISTIVITY PROFILE ACROSS EL NICKLE OREBODY-LYNN LAKE, MAN.
MUSKEG 30' DEEP
1500E
1000E
FIG.4B. RESISTIVITY PROFILE LINE 6000S H.B.M.S. FLIN FLON AREA, MAN.

FIG. 4A, B. Resistivity surveys reveal depth of cover and fracturing.

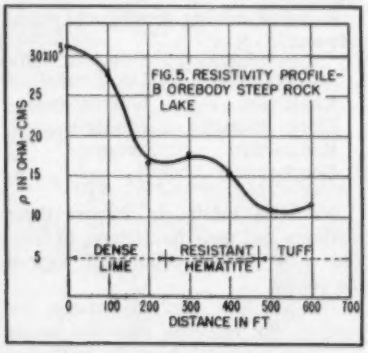

FIG. 5. Note how resistivity drops over hematite orebody.

sistivity method is the fact that the response due to a volume of contrasting resistivity ρ_2, in surroundings ρ_1, is governed by the ratio $\frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$. From Fig. 3 we see that this ratio rises rapidly for low values of ρ_2/ρ_1 and flattens for large. Thus the resistivity response is proportionately large for low resistivity contrast, and does not increase greatly for large resistivity contrasts. Thus small resistivity contrasts cause relatively large anomalies.

Hence anomalies readily occur with changes in surface material, e.g. muskegs and Gila conglomerate valleys are good conductors, with topographic ridges which actually simulate good conductors and with varying thickness of cover. Anomalies also result from minor changes of rock material, rock fracturing, etc. Sulphides when present then need not give rise to exceptional anomalies, and the resistivity method therefore is generally not direct, any presence of mineralization having to be inferred from relative juxtaposition of anomalies and known geology. Frequently it is difficult to determine whether anomalies result from the bedrock or cover conditions.

Nevertheless resistivity methods have been extremely useful, particularly in areas of the younger formations, to give depth of cover, evidences of fracturing, and other factors.

To illustrate the above, Fig. 4a and 4B show a resistivity profile over the Lynn Lake L orebody and a Flin Flon muskeg. They agree within 10%.

Fig. 5 is one of the original resistivity profiles across the tuff-limestone contact at Steep Rock Lake B orebody, evincing the more resistant hematite.

The Buchan's ore zone was extended by the equipotential line technique—a form of resistivity procedure.

Electromagnetic. The understanding of this method is readily derived from the work of J. R. Wait, Geophysics, Vol. 4, No. 6, October 1951, who (Fig. 6) shows how, for any conducting body, the in-phase and quadrature response components vary with the conductivity σ, size of the anomalous body r, and frequency f used accord-

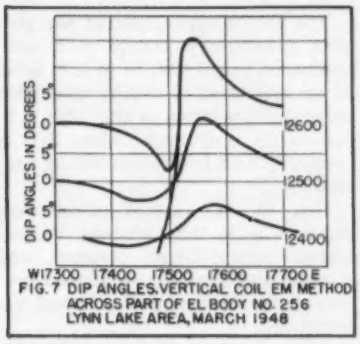

FIG. 7. Response obtained with conventional vertical-coil equipment.

ing to the relation $\sqrt{\sigma f} \cdot r$, see Fig. 6.

Usually a fixed frequency between 400 and 1200 cycles is used whence from Fig. 6 it may be shown that for the average conductivity 10^2 of pyrite, chalco, or galena, a truly disseminated deposit with particles of 10^{-2} meters size cannot be detected. Also it can be shown that broad areas of relatively low resistivity ($\rho = 1/\sigma = 10 - 30$ ohm-meters), e.g. late volcanics as in southwest United States, salt water clays as in Australia, and the dry, evaporatively-salted cover of arid South Africa, Southwest U. S. and South America can give anomalies of a magnitude comparable to many massive sulphide occurrences.

This is why EM work has been largely concentrated in Canada, Sweden and Finland, lands of shallow cover and, strangely enough, higher resistive cover (50 ohm-meters or more).

Fig. 7 shows the response across the EL orebody at Lynn Lake by the conventional vertical coil, 1,000-cycle, ground method used in Canada.

Fig. 8 shows results of the same ground method in exploration using 800 cycles south of the United Verde mine with best orientation of coil relative to terrain. Here any component of terrain slope not perpendicular to the vertical generating coil can cause a response due to the good soil cover. Knowing the terrain, the form of the response can be calculated and here agrees with the response profile, so it is apparent that the response came from the terrain.

To date, the ground electromagnetic method has been effective in exploration for essentially massive or interconnected sulphides as witness the recent aid rendered in the New Brunswick discoveries.

The method has been extended to continuous recording from aircraft by the International Nickel Co. in

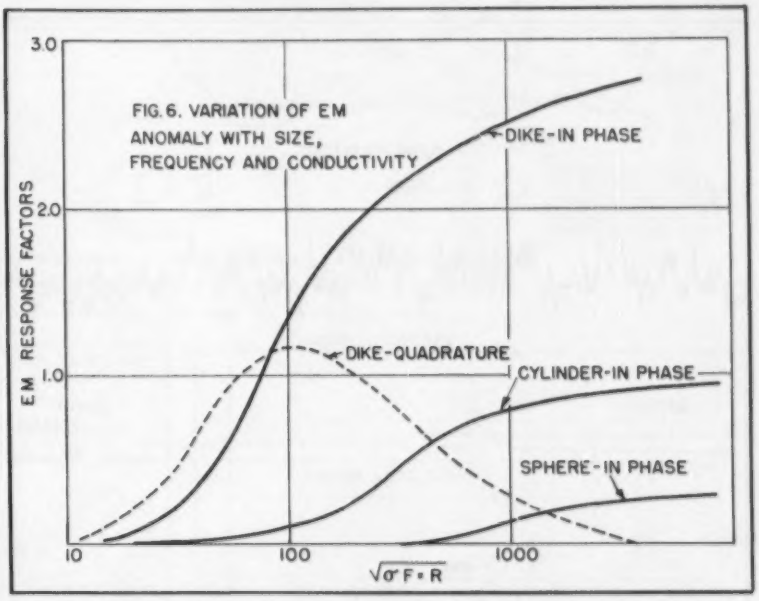

FIG. 6. In-phase and quadriture response components vary with conductivity, size of the anomalous body, and frequency used.

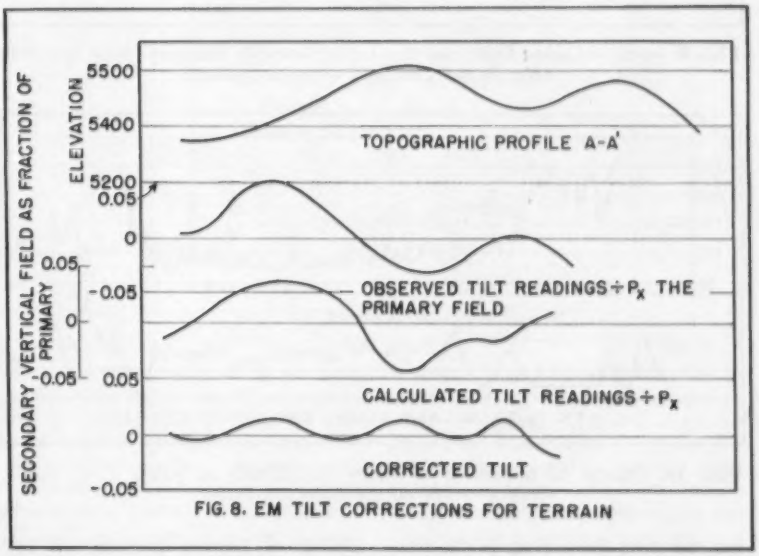

FIG. 8. Any component of terrain slope not perpendicular to the vertical generating coil can cause a response due to good soil cover.

their recent patent 2,623,924, work on which was actually initiated by S. Davidson, A. Brant and the present McPhar group, supported by Sherritt Gordon, Falconbridge, and Ventures. Another airborne magnetic device is being operated by Aeromagnetic Surveys of Toronto, Canada using 2 parallel sets operating at 400 and 2300 cycles and recording as a phase angle the total direct plus anomalous signal versus the direct. Other airborne devices are in development stimulated by Amco's base metal discovery in New Brunswick in connection with one of a series of airborne EM anomalies resulting from their use of the Inco apparatus.

Fig. 9 is a test flight by Aeromagnetic Surveys over the Amco discovery.

Radioactive The key point here is the absorption of the various radiations by the earth and rock materials. Gam-

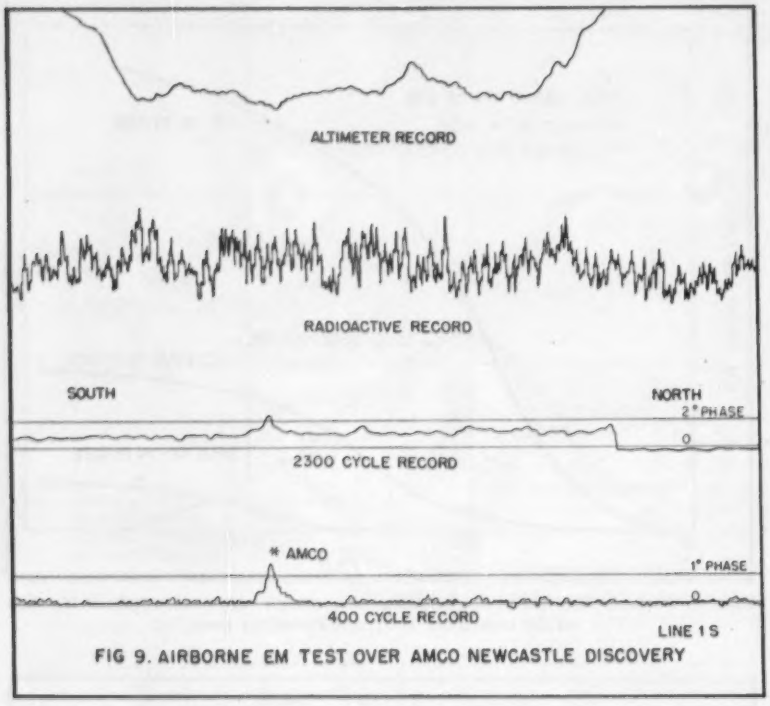

FIG. 9. Results of a test flight over the Amco Newcastle discovery. Note how blips differ in the 2300 and 400-cycle records.

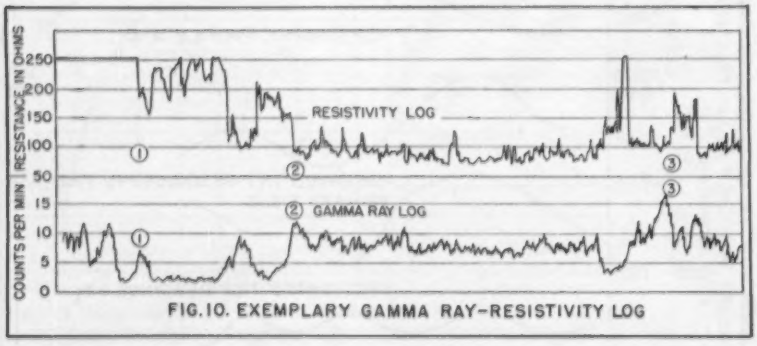

FIG. 10. Change of formations is readily recognizable at points 1, 2, and 3. From a survey on the Colorado Plateau.

ma, the most penetrating of the emissions is reduced to about 1/40 of its initial intensity by 5 ft of average soil cover and to 1/1600 by 10 ft of cover.

Neutron radiations arising underground are readily absorbed in 10 ft or so of water which limits distance for any drill hole work while there is a considerable scattered background intensity over a 45 deg solid angle cone in the atmosphere from cosmic ray showers.

Regarding gamma rays, the research department of the Texas Oil Co. at Houston, who have run tests over many U. S. mineralized areas, feel that there is a perhaps 70% correlation between change of gamma intensity and one time mineralization action. Any such change is, however, readily blanketed by shallow soil cover or later formations.

The early work at Great Bear Lake showed that changes in intensity resulted from change of formation and topography as well as change in thickness of the soil cover.

Thus it is apparent that radioactive prospecting on the ground or in the air will detect only essentially those deposits or areas of increased radioactivity under shallow cover. Nevertheless this has sufficed to aid in the rapid exploration of U. S. uranium resources.

The useful application of the possible gamma ray change with mineralization might well be in drill holes as an indication of nearby associated mineralization much as alteration indications are now used. More data is necessary here before warranting conclusions.

Due to the impetus of uranium prospecting in the Colorado Plateau and elsewhere, Geiger counters, and scintillometers are in commercial production for surface, drill hole and airborne use.

It is rather tragic that the radioactive emanations should be largely stopped by such short sections of earth or rock. Theoretically the radon should diffuse through great thickness or normal shale and sandstone but the limitation here is the slow rate of radon formation.

Fig. 10 is a modern radioactive log with associated resistivity recording from the Colorado Plateau. Change of formation is readily recognizable at the 3 positions indicated. Sandy beds show as high resistivity, low radioactivity; shaly beds as low resistivity, higher radioactivity.

Geochemical This is a present day refinement of the old visual trace or float prospecting and may be applied in a series of forms, although most work done now is along or parallel to the soil sampling techniques and treatments developed by the USGS.

It is imperative that the samples taken contain in some way material derived from the mineral source. In general a mineral source breaks down by solution, (essentially oxidation action) and decrepitation. Thus source material may be carried by actual water transport, ion diffusion in ground moisture, or remain as a soil residue.

The above would preclude detection of a source that has never emerged above the water table and thus never experienced solution, or of a source covered by impervious layers, or by later formations essentially following the original mineral source decrepitation.

Thus at the Bluebird property in Idaho, the residual soils intermixed with transported materials had to be recognized and sampled. Soil sampling has been effective in the shallow cover of New Brunswick but not so in all muskeg areas.

Again the source material spreads out with distance or thickness of cover. This gives rise to down slope or glacial direction fan spreading.

Some host rocks hold the metal solution products better than others: zinc ions in themselves are more mobile

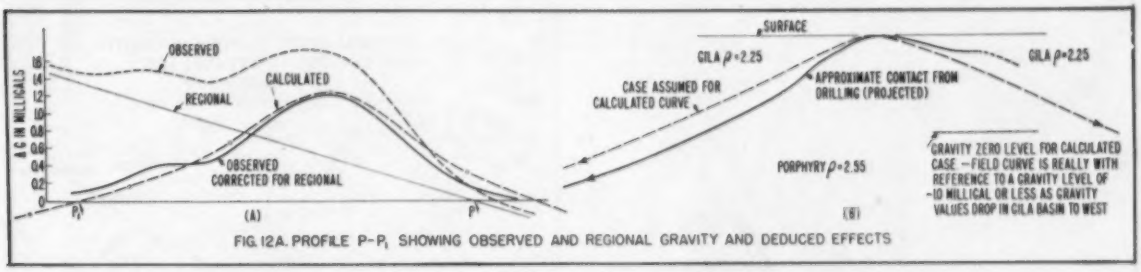
Δ G IN MILLIGALS
OBSERVED
CALCULATED
REGIONAL
OBSERVED CORRECTED FOR REGIONAL
(A)
SURFACE
GILA ρ=2.25
GILA ρ=2.25
CASE ASSUMED FOR CALCULATED CURVE
APPROXIMATE CONTACT FROM DRILLING (PROJECTED)
PORPHYRY ρ=2.55
GRAVITY ZERO LEVEL FOR CALCULATED CASE —FIELD CURVE IS REALLY WITH REFERENCE TO A GRAVITY LEVEL OF -10 MILLIGAL OR LESS AS GRAVITY VALUES DROP IN GILA BASIN TO WEST
(B)
FIG. 12A. PROFILE P-P1 SHOWING OBSERVED AND REGIONAL GRAVITY AND DEDUCED EFFECTS

FIG. 12A. Readings shown in Fig. 12 below were corrected for regional intensity as shown.

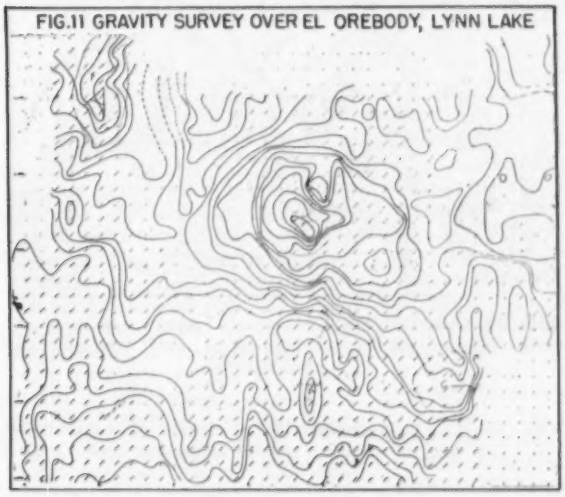

FIG. 11. Gravity anomaly over 6-million ton L orebody.

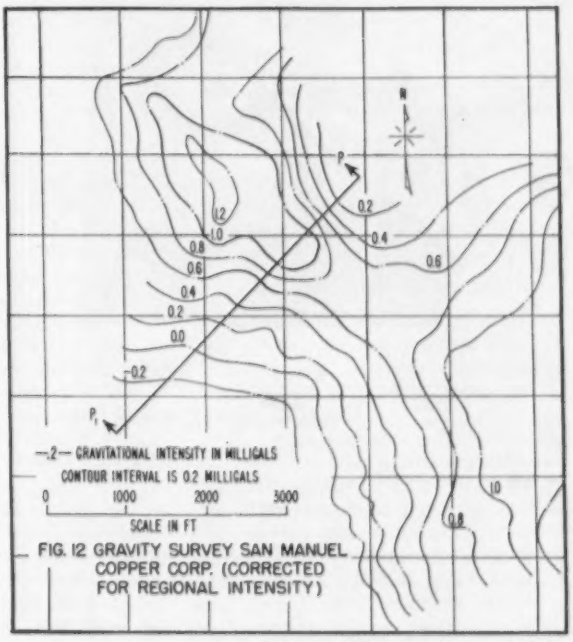

FIG. 12. This anomaly is a reflection of bedrock.

than lead which in turn is more mobile than copper. On the Rhodesian Copperbelt, soils above quartzitic copper bearing rocks may show only 150-200 parts per million while above argillites evince 500-1000 parts per million for about the same grade, against a 75 ppm background. In New Brunswick, watch out for excess zinc in small drainage traps.

At this point it might seem that geochemistry works best in shallow covered areas of residual soil, or for general broad area indications by stream, water or transport fan analysis. The important fact is it can indicate the mineral present (but not necessarily its absence). Stringers, disseminations and contaminations may act like better concentrations. It looks like a powerful tool for rapid reconnaissance.

Geothermal Fluctuations of surface temperature here practically eliminate the use of any quick, simple, surface technique. Also the thermal conductivity contrast between the metallic minerals and rock is only a factor of about 5, whereas electrical contrasts may readily be 100. There is some possibility that the radioactive heat generated by (e.g.) a uranium ore could be used to detect a near miss in a drill hole, but this has not been tried.

Earth temperature measurements and studies on regional scales should give us some better and useful idea of geologic processes initiating folding and intrusion but this is in the future.

Gravity Here a considerable volume and density difference are necessary to produce an anomaly. Thus massive sulphides or iron are about the only occurrences of ore that could possibly be detected.

Corrections have to be made for topography, and for station elevation. This however does not eliminate anomalies that can arise at the bedrock surface because of density differences between the cover and bedrock.

Fig. 11 shows a gravity survey over the L orebody of some 6-million tons at Lynn Lake. Average density of the body was 3.3 g per cc. The numerous lesser anomalies which still might represent sulphide bodies of appreciable size are actually due to bedrock ridges under the muskeg.

Fig. 12 is a gravity coverage at San Manuel. The anomaly is a reflection of the bedrock as an outcropping ridge dipping off under Gila conglomerates.

At Labrador the dense chert iron formations with 20-30% iron gave the maximum anomalies of about 0.5 milligal. Lower more irregular anomalies generally on strike were actually indicative of higher iron content.

Difficulties in mining application are the relatively large volumes required to give measurable responses above errors arising from generally rough terrain, and the anomalies, difficult to correct, due to bedrock topography and varying thicknesses of cover.

Gravity work has been useful in iron country, both in Labrador and

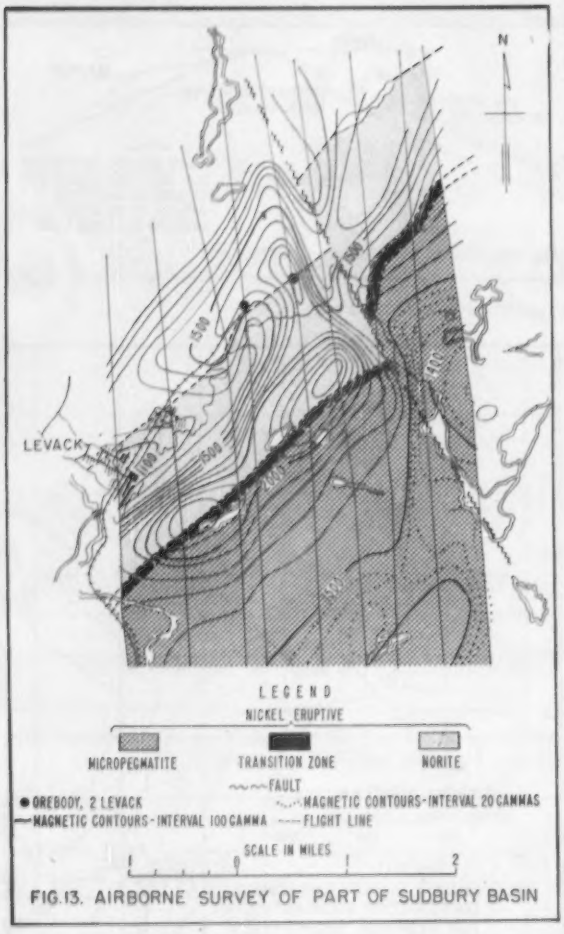

FIG. 13. AIRBORNE SURVEY OF PART OF SUDBURY BASIN

Minnesota. It has been used for massive base metal exploration in the Noranda, Sudbury, and Bisbee areas. However, the main applications have been limited and in general, indirect, as, for example, outlining the ore controlling denser diorite at Jerome, the less dense areas of increased fracturing or solution alteration as in the Tri-State, and the thin portions of the covering volcanics on the Rand extension into the Orange Free State.

Test work has shown that large scale geologic folds, grabens, etc. frequently show up gravitationally. This may have eventual useful regional application.

Successful work has been done underground at Bisbee in detecting massive sulphides in the limestone-porphyry complex which fortunately is of consistent density.

Magnetic. World wide, this has been one of the most useful mining geophysical methods even though it is indirect, magnetic anomalies generally being referable to formations rather than to mineral bodies except in the

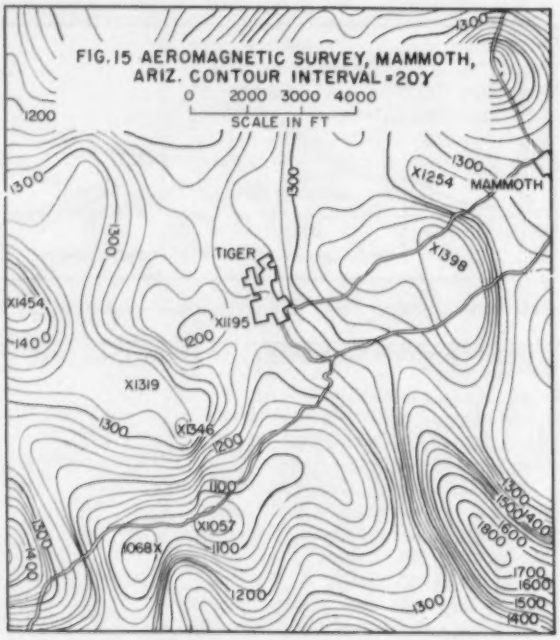

FIG. 15. (ABOVE) The aeromagnetic pattern here is essentially due to varying thicknesses of Gila conglomerate. See also Fig. 16.

FIG. 13. (LEFT) Anomalies in the vicinity of the orebody are due to magnetite in volcanics and norite.

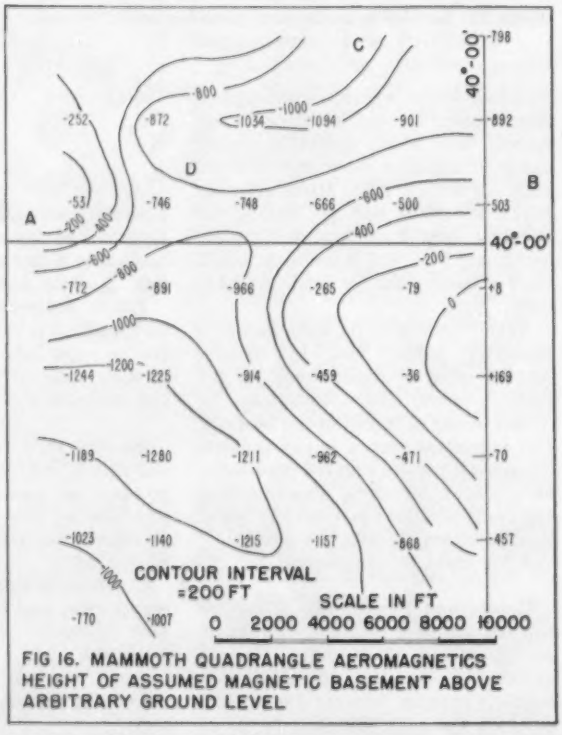

FIG 16. MAMMOTH QUADRANGLE AEROMAGNETICS
HEIGHT OF ASSUMED MAGNETIC BASEMENT ABOVE ARBITRARY GROUND LEVEL

FIG. 16. Thicknesses of the Gila conglomerate have been mathematically derived.

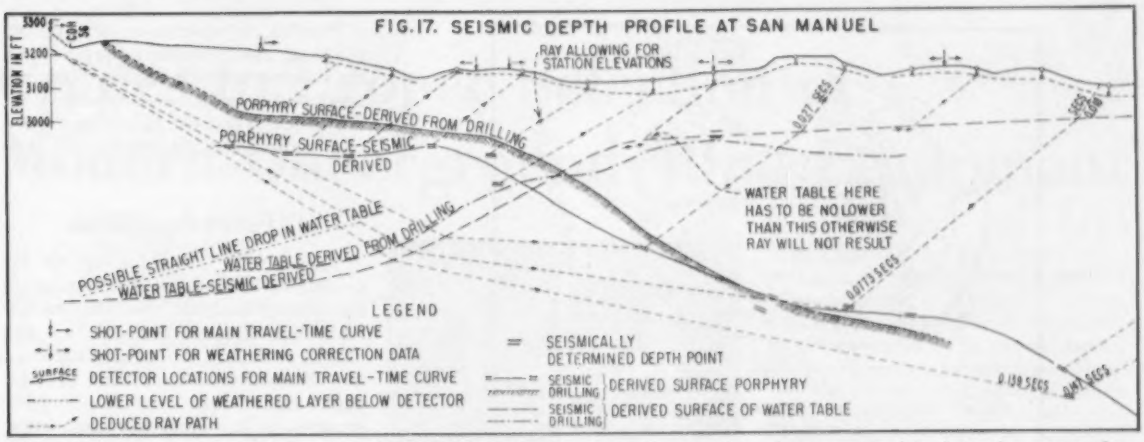
FIG.17. SEISMIC DEPTH PROFILE AT SAN MANUEL
ELEVATION IN FT
3300
3200
3100
3000
RAY ALLOWING FOR STATION ELEVATIONS
PORPHYRY SURFACE-DERIVED FROM DRILLING
PORPHYRY SURFACE-SEISMIC DERIVED
WATER TABLE HERE HAS TO BE NO LOWER THAN THIS OTHERWISE RAY WILL NOT RESULT
POSSIBLE STRAIGHT LINE DROP IN WATER TABLE
WATER TABLE DERIVED FROM DRILLING
WATER TABLE-SEISMIC DERIVED
0.077 SECS
0.073 SECS
0.138 SECS
LEGEND
SHOT-POINT FOR MAIN TRAVEL-TIME CURVE
SHOT-POINT FOR WEATHERING CORRECTION DATA
SURFACE DETECTOR LOCATIONS FOR MAIN TRAVEL-TIME CURVE
LOWER LEVEL OF WEATHERED LAYER BELOW DETECTOR
DEDUCED RAY PATH
SEISMICALLY DETERMINED DEPTH POINT
SEISMIC DRILLING DERIVED SURFACE PORPHYRY
SEISMIC DRILLING DERIVED SURFACE OF WATER TABLE

FIG. 17. This seismic profile at San Manuel shows how the refraction method may be used to determine depth of cover. Short surface shots were used to determine near-surface velocities and layerings.

case of iron, nickel and titanium illmenites. However, mineralization and alteration are not infrequently accompanied by changes in magnetic property.

Basic rocks are generally more magnetic than acidic, plutonic more magnetic than sedimentary. Most rocks are of relatively low magnetic susceptibility, so that topography and cover considerations can frequently be neglected.

However the broad late Crétaceous and Tertiary areas from southern Utah into South America present a series of covering lavas that are frequently magnetic and effectively blanket much of the area to magnetic exploration. Also the broad Gila filled valleys are of such dimensions as to cause marked magnetic expression and again make (e.g.) airborne work, of very limited value.

The more extensive and useful application of magnetics then, has been in the older formation areas of the Canadian and Scandinavian shields and the South African plateau.

As examples, Fig. 13 shows an airborne survey section of part of the Sudbury Basin. Represented is an orebody area and anomalies due to scattered magnetite in the volcanics and norites.

Fig. 15 shows airborne results over San Manuel. That these are essentially due to the varying thickness of Gila is clear from Fig. 16, where the necessary thickness of Gila to account for the magnetics have been mathematically derived by an extension of the continuation downwards procedure of Peters, *Geophysics*, Vol. XIV, No. 3, 1948.

The usefulness of magnetic methods, despite these limitations, are exhibited by O. Weiss' work tracing the iron formations into the Rand Extension, the extension of the Chesterfield Inlet Nickel zone, the discovery of the first Lynn Lake nickel bodies Canada, the outlining of the ilmenites at Allard Lake, Quebec, and the discovery of magnetite near Morgantown, Pa., and Marmora, Ont., the last three resulting from airborne work by Aero Service Corp.

Seismic. The seismic method has been seldom used in mining work.

One of the main applications is for determining depth of cover, and Fig. 17 shows a cross section derived southward from the North San Manuel shaft. The procedure was a series of refraction shots with short surface shots to determine near surface layerings and velocities. Knowing these and the emergence angle, the ray can be drawn back downwards from the pick up. The velocity in the bedrock is apparent from the refraction shots and the only unknown is the thickness of the lower layer of cover. Knowing the total travel time to the station permits the depth to bedrock to be determined and the dip of the bedrock.

Orebody detection was tried at the Chief Consolidated mine, Tintic, by H. H. Pratley of National Geophysics, using the slower velocity of the brecciated and crumbly ore area to provide a diffracting shadow defined from the emergence angles. Here the smallest size that can be detected is given by

$$\sqrt{\frac{dv}{f}}$$ where d = distance from body,

v = wave velocity and f = frequency. Only a low frequency, about 60 cycle per second was tried.

This possibility, and checking on ore continuity, exists seismically with more hope at higher frequencies, although above a few thousand cycles, dispersive effects at small fissures, etc., become extreme.

III. Present Developments

So much for the past and much of the present. Recent developments are the airborne magnetic, electromagnetic and scintillometer devices previously mentioned.

In connection with magnetic work, the mathematical means whereby results are converted to those at higher or lower elevational levels, as long as outside the anomalous volume, is of great value. A case of this was the derivation of thickness of cover from the San Manuel airborne results.

Some interesting electrical developments are taking place. In resistivity, tests have been made to roughly determine the size and continuity of conducting sulphide orebodies. In both cases the orebody is contacted by the one current electrode and a nearby potential. Measurements are made to the far potential, on line of strike or in the other showing, if continuity is desired, or in other underground workings or drill holes, if size is desired.

Fig. 18 shows the potential thus derived relative to an ore intersection of some 10 ft in a drill hole. The size of the intersection is readily computed from

$$P_1 \overset{\triangle V}{} P_2 = \frac{\rho ore}{4\pi} I \left(\frac{1}{r_1} - \frac{1}{R\ ore}\right) + \frac{\rho\ rock}{4\pi} I \left(\frac{1}{R\ ore} - \frac{1}{r_2}\right)$$

where R is the radius of the equivalent spherical orebody, r_1 and r_2 are the distances to the potential electrode

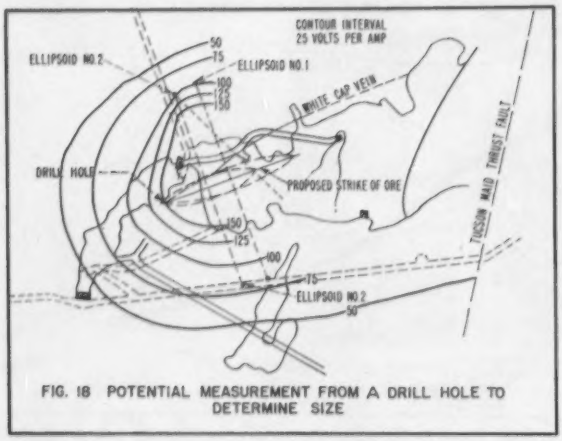

FIG. 18. Here the potential method was used to determine the size of an intersected orebody.

pickups in ore and rock from the current electrode in the ore, and ρ^{ore} and ρ^{rock} are the known resistivities of ore and rock. In this case size worked out to 3,000-4,000 tons. The latter was obtained.

Also it is possible to predict the azimuth of a conducting body near a drill hole or drift. Current electrodes are placed on a line in a plane at right angles to the hole or drift so that the hole or drift is midway between them. The potential is then measured between a movable pickup in the hole and one far away. Fig. 19 is the result. If the polarity of the current electrodes is known, the azimuth of the conducting body can be deduced, for the potential will be more positive opposite the body if the body is on the positive current side.

Work has been going on with methods to detect scattered sulphide mineralization, most methods heretofore being adapted to massive sulphide bodies, or being dependent on some indirect association as (e.g.) associated magnetite. Fig. 20 shows the deduced percent by volume of sulphide mineralization and depths to sulphide at a porphyry copper prospect in Southern Peru.

Parallel developments are taking place in electromagnetic prospecting for massive sulphide bodies. Size and azimuth determinations are possible in drill holes. There are at least two ways of accomplishing the former and several for the latter.

IV Future Possibilities

The future is not going to be marked by the sudden development of exceptional methods. Nothing on the immediate horizon indicates an approach to mining geophysical exploration that will solve the present existent depth limitations. Laboratory phenomena do, however, give some hope that other methods besides geochemical may eventually indicate the nature of the material or ore present.

All in all, it looks like continuing gradual development on all fronts; in equipment, interpretation and better understanding of cases, rather than the sudden burgeoning of any exceptional techniques.

Continuing attempts will be made to make the various methods airborne essentially with helicopters to permit low "grouse" flying. Rapid reconnaissance application will be stressed. We will work more and more from the outside in, as the oil people do. Within the Americas, Europe, and Africa, a slow breakdown of political barriers should evolve with slowly increased ease and interest in "foreign" exploration by American companies.

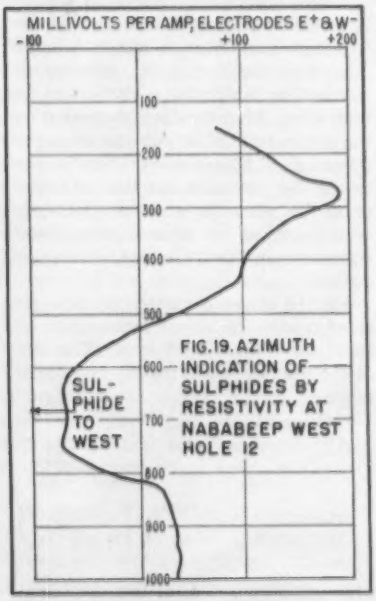

FIG. 19. Current electrodes were used to predict azimuth of orebody.

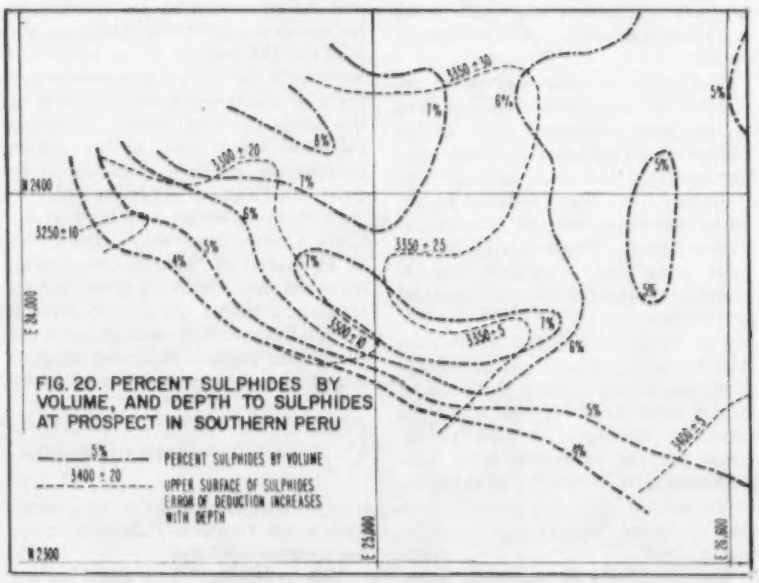

FIG. 20. Electrical methods were used in southern Peru to deduce percent by volume of scattered sulphides.

Guides to Proper Selection of Modern Underground Mine Equipment

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Salt Lake City, Utah

Art Work by
ROSS PLAYER

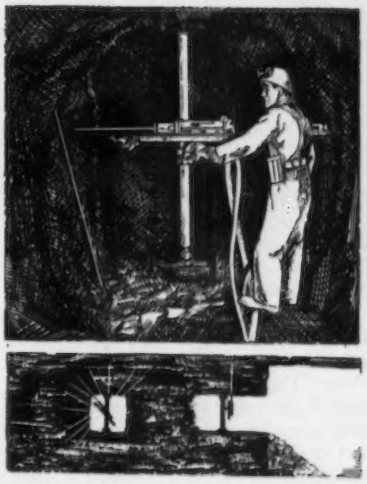
BEFORE A STREAMLINED modern mechanized mining project is organized, mine planners must appraise the applications, limitations, advantages, and disadvantages of the equipment available to them. This article has been prepared to aid in making such appraisals and to point out some significant areas where today's mining machinery can be improved to yield peak production.

A quick look over the past 30 years reveals the momentum that has been given to improvement in labor-saving equipment. Thirty years ago some companies were experimenting with their first two-drum slushers. At the outset buckets were poorly designed and inefficient. Slusher ramps were installed to cut down hand-mucking in drifts. The first compact overshot drift mucker had just been built. Laborious hand-crank, column-mounted drifters were standard equipment in most mines. Early detachable bits were being compared with conventional steel. Hard hats, hard-toed shoes, electric cap lamps had yet to see full-scale acceptance. Lighter, compact utility hoists and improvements in haulage equipment were under study.

Progress Could Be Faster

But despite impressive advances in mining during the past 30 years, progress has been slow when compared with that in other industries. Great opportunities still exist to do the job faster, easier, cheaper, and more safely. This challenge is being accepted by manufacturers today who are producing streamlined, highly productive equipment. Naturally the emphasis must be on those units which can be mass-produced.

In this respect the over-shot, wheel-mounted mucking machine is a good example of a mass-produced unit which soon gained widespread acceptance by labor and industry. For small crosscuts up to 8 x 8-ft or 8 x 10-ft, these rugged, compact, hard-rock machines are still a favorite. Until the day there is a change in rock-breaking methods, and blasting cycles are eliminated, or until uninterrupted continuity of face advance is realized, this unit will hold a strong competitive position.



BAR-MOUNTED DRIFTERS are moving out of the drift in favor of jumbos, but finding new uses in stopes.

Savings resulting from the adoption of these rugged machines have stimulated strong interest in other cost-cutting labor-saving devices now being offered in increasing quantities to mine operators.

For at least forty years, drifters, 3-in., 3½-in. or 4-in. bore machines, have been mounted on the crude, cumbersome, heavy, awkward, time-consuming, vertical bar-and-arm combination that has remained almost unchanged. These are fast becoming outmoded for drift haulage heading work.

Drifters improved successively from hand crank to vibration feeds to motor drives and to long feed shells, but the old steel vertical bar and arm has remained the same even to the details of the chuck nut size, the chuck wrench and the method of tightening the bar.

For drilling in drifts, particularly in harder ground, the 3-in., 3½-in. or 4-in. model drifters, mounted on portable streamlined easily transported quick-into-action drill jumbos that eliminate hand holding of drills to any degree, are the recommended standard. These jumbos are mounted on rail, rubber tires, or crawlers. This combination permits better control of drill hole direction, and utilizes positive direction guides for longer and deeper holes. Single length steel is being used increasingly to drill the full length of the hole to eliminate intermediate changes of steel. These machines are operated by remote power controlled feeds, directly by power-actuated booms that nearly eliminate hand handling of steel and reduce heavy labor-consuming work of drift drilling.

This type of equipment eliminates the setting up and tearing down time of a conventional bar and arm, and allows the miner to complete the job with even less effort than with the semi-hand held air leg mounted type drill. Heavier drilling equipment can be used as the mobile mounting eliminates hand transporting of any of the equipment. The mobile jumbo, properly equipped, is recommended for doing this job in metal mining operations.

New Crawler Loader

Recently, a crawler-mounted, air-operated, compact, overshot type loader with the same features as the wheel-mounted units has been introduced in several western metal mines. This type of mounting is new for small-sized loaders, and this added feature will be an improvement for drift driving work. The crawler mounting gives additional flexibility for cleaning sides of a drift and can be operated either ahead of the track or with trackless haulage.

Adding to this unit, an integral, compact jumbo might readily allow the crawler mounting to perform two functions. In a drifting operation, particularly when the loader cannot be moved economically to other headings for continuous or multiple loading service, it is reasonable to foresee some type of telescopic drill jumbo incorporated into the basic design of the loading unit. (*Please turn page*)

THE AIR-LEG DRILL is the jack-of-all-trades unit where heavier multiple jumbo units won't work.

A drifting or cross cutting project on the haulage horizon, or where rock-volume to be removed is large, calls for larger, heavier drills with long positive feeds mounted on jumbos.

Another recent introduction and one making inroads into metal mine loading in undulating bedded deposits, is the Gismo, a development that had its beginning in metal mining. This crawler-mounted loading and hauling unit is actuated by a separate crawler diesel-operated tractor. The loading mechanism employs few working parts.

One possibility that might increase its field of application would be the incorporation of an integral power unit within the body of the machine.

The result would be an inexpensive type loading head mounted on somewhat the equivalent of a self-loading buggy, or if on rubber tires, would possibly resemble a modification of a front loading Carryall or Tournapull.

The theories being developed in this machine with its simple loading principle, could be the forerunner of one of the compact self-loading underground transport machines for inclined and flat bedded slopes as well as in drift heading work. The unit is also used as a jumbo mounting for long sash automatic drills.

Multiple Drills

Multiple holes completed fast, speed mine production cycles and insert tungsten carbide bits have increased the depth a hole can be drilled without changing steel. This is the case, not only in drifts, but particularly where greater footages are to be drilled in wider areas that can be reached by jumbos, as in the blanket type flat or slightly dipping ore deposits.

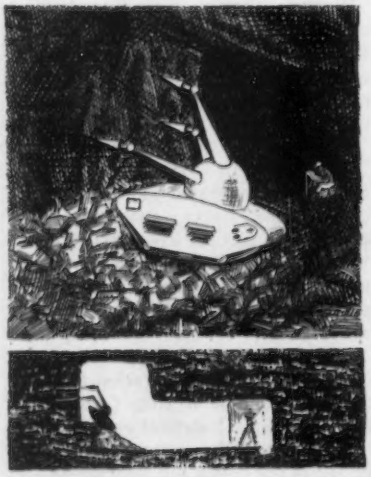
In either case, the facility for movement without requiring track offers more flexibility in mining. A crawler or rubber-tired mounting on a jumbo gives that greater necessary flexibility to the drilling operations.

The air-leg drill has many applications in drifts and crosscuts where hand transportation is used to move equipment into the working face. It is a flexible, handy drilling combination for drift work, whether on the haulage level or in sub-level exploratory openings. It is a jack-of-all-trades, general utility machine for use where heavier multiple jumbo setups are not feasible. They are particularly adaptable for drilling roof bolt holes.

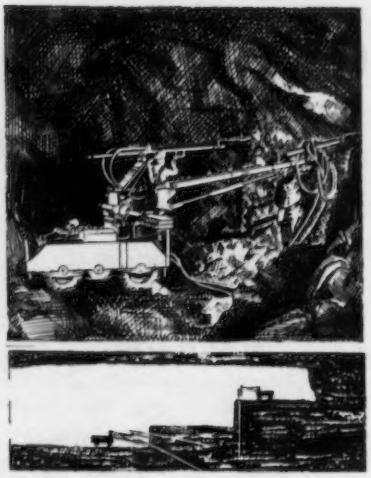
This light machine with supporting feed combination is an improvement over anything in the light-weight drill class. They are used with small section, light-weight steel, small-diameter bits, often of the tungsten carbide insert type, to drill small holes at fairly rapid speeds.

Still it is basically a hand-held machine and imagination would call, eventually, for an automatic remote controlled mounting that would eliminate hand labor to hold, guide or balance the machine.

Drill bits for percussion drilling are divided between the one-use, throw-away type of bit and the tungsten carbide insert bits, particularly conventional steel with integral insert bit. The aim is to eliminate mechanical troubles and loss of power due to bit connections.



LOOKING AHEAD, maybe we can expect a fully automatic, remote-controlled crawler unit such as this.



MULTIPLE JUMBO UNITS offer advantages of speed and versatility not yet fully exploited.

In hard rock the tungsten carbide insert type of bit is recommended. In softer ground the one-use bit is competitive. But the ultimate is a bit that will last out the entire life span of the drill rod.

Drill steel, in ground that is semi-hard or hard, used in connection with a 3-in. or 3½-in. or larger drifter, finds the 1⅛-in. and 1¼-in. round steel or 1-in. quarter octagon with about the same strength as 1¼-in. round drill steel, the sizes that give the most satisfactory service. This is particularly true where a single long steel is used to drill the hole.

It is desirable to lean toward lighter section steel where steel or drilling equipment are moved by hand.

Motor Haulage

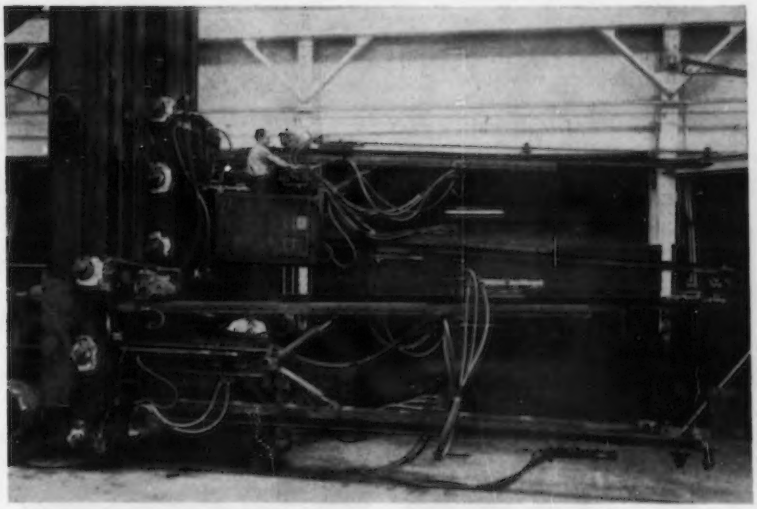
In underground mine locomotives for car haulage service, four types of motors are in use.

The largest percentage of locomotives are battery-operated units.

Air-operated locomotives are used for drift and crosscut car-heading service jobs. They are relatively inexpensive as compared with the initial cost of the electrically operated machines. Air units are effective for travel distances of 500 to 750 ft, and longer distances for prospecting. For production service, 750 ft is about their efficient limit.

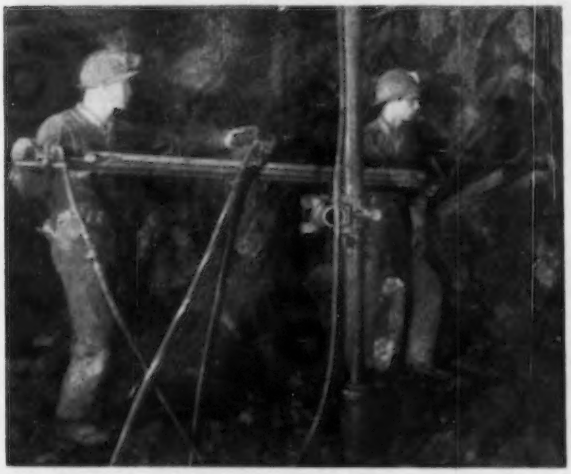
The battery locomotive, even though it hauls considerable dead load in power storage, is by far the most popular and widely accepted locomotive for general underground mine service.

The trolley locomotive is not loaded

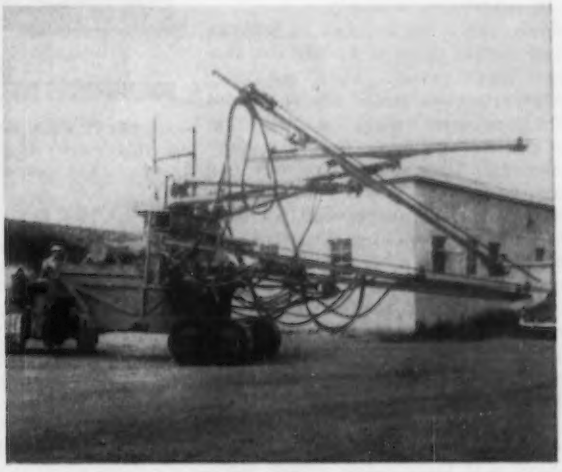


A NEW HIGH IN MINE MECHANIZATION. Long-sash drills eliminate steel changes and take full advantage of tungsten-carbide bits. Both drill and drill operator may be positioned by the completely mechanical fore-structure of the jumbo.

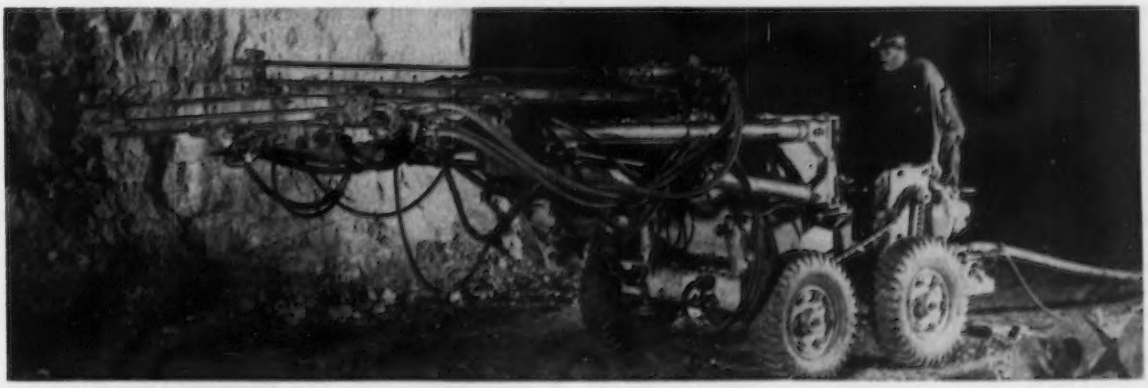
FLEXIBILITY AND LIGHT WEIGHT have dictated widespread acceptance of the feed-leg all-purpose drill.



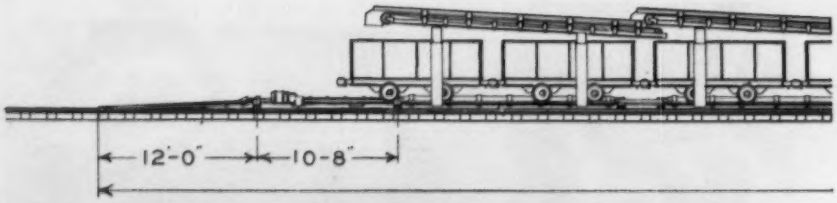
THE LARGE DIAMETER PNEUMATIC CYLINDER at the base of the column eliminates much of the hard work of setting up, and assures a firm drill mount which will not rotate.



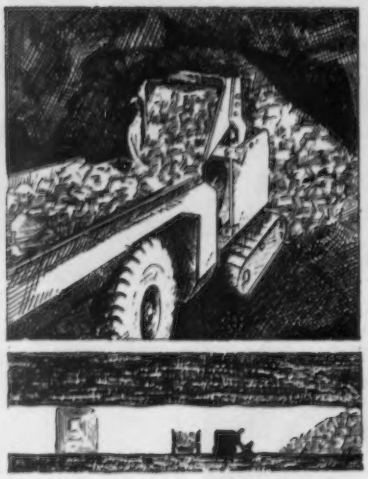
THE COST-SLASHING GISMO shown here completely mechanizes the mining process including drilling, loading, and hauling. Maneuverability is a big advantage of the unit.



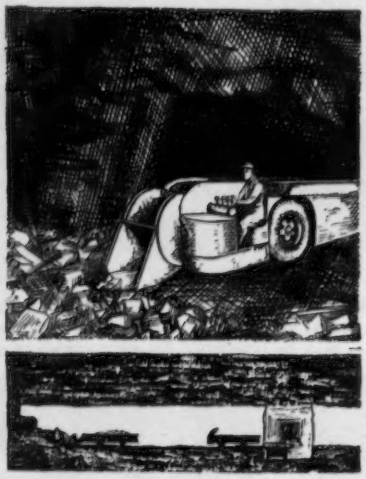
OVERALL DRILLING TIME IS CUT with this rubber-tired self-propelled mobile drill unit carrying long-sash drifters with automatic positioning devices. Mobile drills can travel freely in irregular stopes, and if exploited fully can drill both horizontal and vertical holes as shown on page 34, for added flexibility in difficult mining problems.



THE OVER-SHOT LOADER could be designed to load itself for short shuttle runs in stopes as shown above. . . .



. . . OR IT CAN WORK as a team with a rubber-tired shuttle car in flat ore deposits. . . .



. . . OR IT MIGHT BE MOUNTED on the front end of a shuttle car to combine loading and hauling in one unit.

down with a ton or more of batteries and utilizes more of its effective motive input power. They are more efficient because power available is not apt to decrease during the shift. From a power standpoint, they are more efficient. They serve best on long transportation hauls, particularly where men and supplies do not have to come in possible contact with the trolley wire, and where the fire danger is not a critical consideration.

Trolley motors are generally higher speed haulage machines. They operate at speeds of 8 to 15 mph. The range of the battery-powered machines is from 4 to 6 mph.

In general, car haulage is moving toward the use of heavier rail, higher speed, with large radius curves, automatic block switches and a central control of the whole underground haulage network by trolley phones or radio.

There are many designs of mine cars, and their selection depends largely on the type of material to be handled. It is recommended that for material of a gravity, free-running type, a mechanical self-dumping car such as the Granby 5th wheel and ramp-actuated automatic dumping car should be considered.

In tunnels, shallow blanket type mining operations, particularly where ventilation is ample, the diesel locomotive is offering more competition and is a definite recommendation where rail and cars are applicable. Their main drawback is requirement of adequate ventilation and trouble-free scrubbers. Regarding scrubbers, this is a field that is open for development and improvement, and if the toxic products of diesel combustion could be held out of the air stream, the possibilities for diesels, not only on underground locomotives but on innumerable other motor installations, would be almost unlimited.

Air Leg Drills

In stoping, air-leg drills came into the picture to replace column mounted machines. This type of light, flexible mounting has a decided application in lighter shorter jobs as the air leg mounting drastically cuts setup time.

With these machines in a high percentage of stope work and sub-level projects, particularly where portability is a factor, more work is performed per man shift at an overall less cost than by machines with other mountings.

In large stopes, or sub-levels where holes of over 25 ft are required, the column mounted drifter machine with coupled steel has a field yet untouched by other percussion drills. Holes 25 ft to 100 ft are successfully drilled from a column bar setup. They are also used for prospect holes and as pilot holes ahead of workings being advanced into new areas.

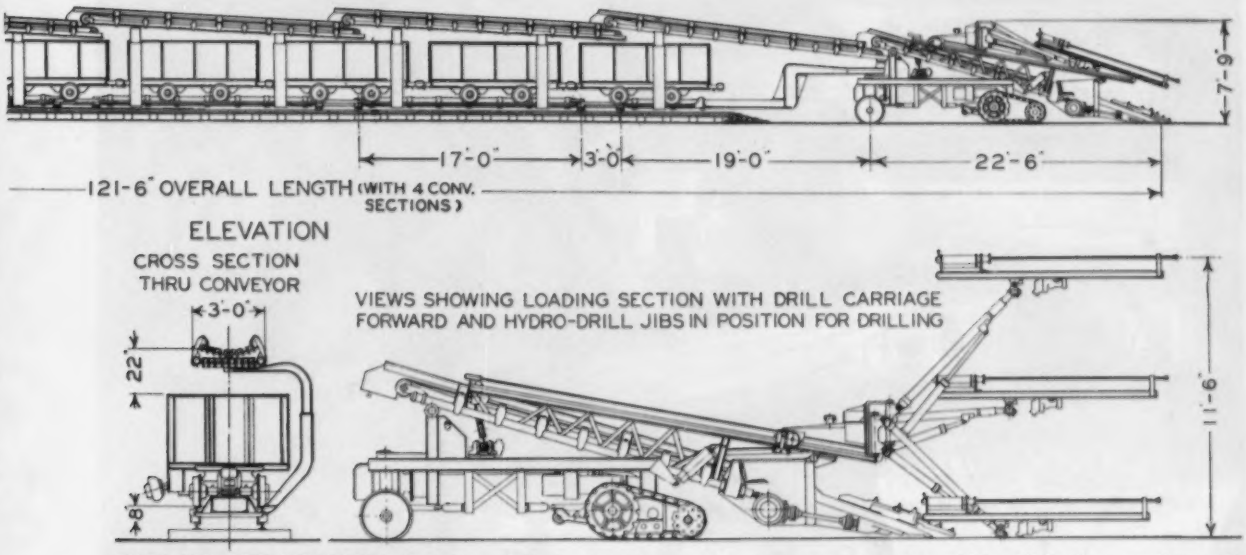
Reversible feed drifters which feed or remove coupled drill rods are a successful recent introduction. This equipment could be improved with:

1. Column bar ½ the weight of the present all-steel units.
2. Air or hydraulic operated tightening and holding mechanism.
3. Arm actuating device air-operated to enable automatic changing of the position of the drill. Once set up for long holes or for large amounts of drilling in one area, particularly where the rock is hard, holes are drilled from a rigid setup faster and easier than with the air leg or semi-positive type feed machines.

For a number of years, diamond drills were economical to use and competitive for drilling long blast holes in stope work. They were competitive costwise to the drifters using coupled long drill steel. The economics have changed because the cost of diamonds has increased almost 2½ times in recent years. With the introduction of tungsten carbide insert bits, performance and costs have improved for long-hole drilling.

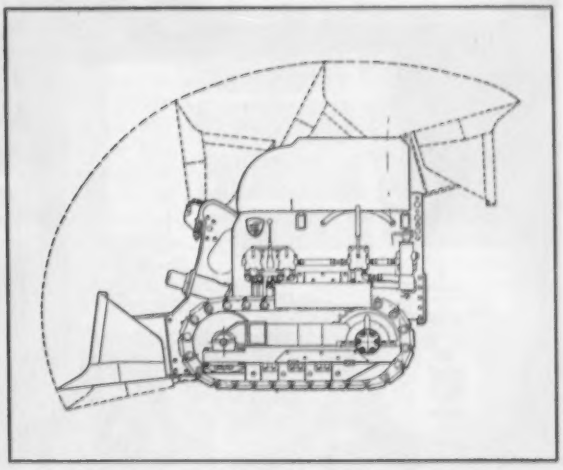
Diamond Drills

The field for diamond drills underground is in exploratory work where



JUST OFF THE DRAFTING BOARD. This new drilling-loading jumbo will cut hours from mining cycles. Note the extensible conveyor system which will load a complete train of underground mine cars at one time.

CONTINUOUS MINING IS HERE, at least in the softer non-metallic orebodies.



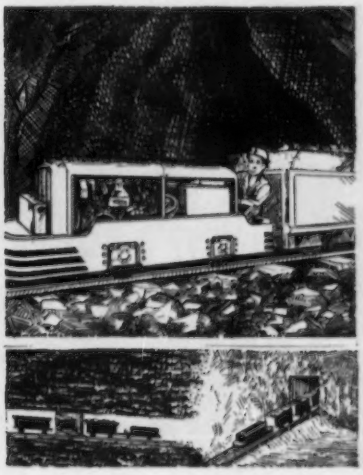
NEWLY-DESIGNED front-end loader features a bucket 4 ft 7 in. in width.

DIESEL LOCOMOTIVE teamed with automatic side-dump cars speeds up the haulage cycle.

TRACKLESS MINING with loaders and shuttle cars increases production in irregular orebodies.

VERSATILITY OF THE SCRAPER accounts for its widespread adoption in mining.

COMPRESSED-AIR LOCOMOTIVES are ideal for gathering and short hauls.



IMPROVED SCRUBBER DESIGN broadens the use of diesels underground.

LARGE LONG-HAUL PROJECTS find electric locomotives highly efficient.

piston-type air-motor power drills with high lugging power at slower speeds, give the operator graduated control of his drilling speed and closer care of the expensive bits. Electric machines in comparison weigh more. Delivering power to them offers additional problems.

Drills

Stopers of the rotating type are unchallenged for drilling holes vertically overhead in raises and stopes. They utilize air piston operated feeds and once in operation require little control or support by the workman. In some cases the air-leg mounted drills are pressed into certain special fill-in jobs of stopers.

Slusher Hoists

Slusher hoists are probably the most versatile of all the various types of transfer and loading equipment. This is one field that has made fast and definite progress.

Primarily, this is true because the slusher has a wide range of uses. It is flexible, as it performs and combines three separate functions:

1. Gathering. The properly designed bucket will gather a load and, once filled, will partly raise and move the load without creating a plowing action or without losing its load.

2. Hauling and Transporting. Once loaded, it acts as a haulage or transporting medium moving over undulating surfaces, up or down slopes, at speeds up to 450 fpm.

3. Loading into cars or other conveyances. This includes dumping into chutes or transfers to complete the full cycle of performance. They are extremely simple to operate and are adaptable in one phase or another in practically every mining method being practiced today. They are low in initial cost, their upkeep costs are modest, and they are simple to operate.

Slusher hoists vary from 5 to 150 hp with graduated blade or sizes of bucket varying with the job to be done, length of haul, size of material and nature of material being handled. Bucket sizes vary from 30 to 84 in. in width and weigh from 200 lb to 2½ or 3 tons.

They are used as straight transfer machines, with one bucket or at times on long hauls, with two buckets in tandem. They are operated by remote control and as automatic units.

They are applied in loading into chutes from sub-level drifts, stopes, and as transfer units in scram drifts under sub-level caving, block caving and top slicing areas, as well as a multitude of applications in other systems of mining.

Scrapers haul out of sumps, down slopes, dump directly into cars, onto belts or into storage pockets. They are powered with air or electricity. Models are available with rope pull of 1,500 lb at 450 fpm to others with rope pull of 12,000 lb at 450 fpm.

Air slushers are best suited to small jobs where portability is required and tonnages and distances are low. Air units seldom exceed 20 hp. For units exceeding this horsepower, electric drives are preferred. Popular air-operated slushers range in horsepower from five to fifteen, with pulls from 75 to 125 ft over the same range. Performance of electric slushers is superior to that of air-powered units. They offer greater rope pull for weight of machine, and operate at higher speeds.

Generally, quarter-box hoe-type rigid scrapers have the widest range of usage, and are by far the most popular. The folding scraper is successful in confined transfer areas, particularly in scram drifts. Here the bucket can slide back freely over surge piles below finger raises and pick up a full load on the pull. Sides are not needed on these buckets as the scram drift walls tend to keep the ore from spreading.

Three-Drum Hoists

Three-drum units are properly applied in areas with mining widths of over 15 ft, particularly where the bucket must be maneuvered for clean-up work. They are excellent in cut-and-fill stopes for moving broken ore into chutes, and serve effectively to spread fill uniformly in the mined out or completed cut. Other applications include long-wall work and driving flat winzes or inclines.

Conveyors

Conveyor belts find their main application where large tonnages can be moved steadily for set distances. In metal mines the material should be crushed to avoid damage to the belt. Wet material sticks to the belt and limits the grade on which it can operate.

Conveyor belts are best suited to main line haulage of large daily tonnages over long hauls. Some success-

ful installations are now over five miles long.

This field is now growing. Sectionalized and extensible belts, easily transported, will be installed in greater numbers in metal mines, particularly as they are improved to handle mine-run rock and withstand abrasion. Thus they will move into the gathering field as well as the main haul.

The two-bearing flexible suspension idler with neoprene disks mounted on braided steel cable is a progressive development in conveyor design. Thin ribbon steel, approximately the width of the belt, covered with a coating of newly developed shock-absorbing material is now under experimental development to enable belts to withstand shock and abrasion.

Shaft-Sinking Equipment

Riddell's patented mucker for vertical shafts is an accepted standard. This unit with its clamshell bucket, air operated reversible single-drum hoists and maneuverable carriage has eliminated much of the labor involved in shaft mucking. The only drawback is the necessity of timbering close to the bottom.

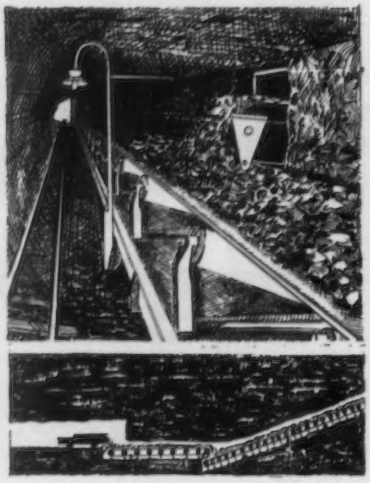
Major Trends

The coal mining industry with its vast tonnages of coal exploited each year has offered large markets for special mining equipment. The heavy cost of design and development of this special equipment was possible for manufacturers because they could see a large sales potential, particularly because of soaring labor costs.

As these machines proved successful in the coal mines, it was natural that such equipment should be modified and tried in similar bedded metal and nonmetallic mines. Thus there has been a gradual evolution of this equipment from coal to salt, potash, bauxite, iron ore, copper and lead ore. Often auxiliary equipment had to be developed before a major change could be made in a mining method adopting the new equipment.

Rock Bolts

Size of loading and haulage equipment is directly dependent upon the size of the mine openings in which the equipment is to be used. Introduction of rock bolting has eliminated timbering, and in so doing has provided greater working space for equipment. Roof bolting should be approached experimentally. Possibilities of this technique should be reviewed for all areas requiring artificial support.



BELT CONVEYORS are now being adopted for gathering as well as hauling.

Coal mining has benefitted by the evolution of crawler-mounted or tire-mounted high speed loaders with low-level gathering heads that load onto a conveyor at 10 to 12 tpm from floor level into cars, onto belts, into shuttle cars, trucks or other haulage units. Similar units are now working in flat-bed iron ores in combination with two or three shuttle cars to provide a balanced flow of material in the gathering operation.

Their application is in flatter bedded deposits of material not excessively abrasive. The numerous operating parts are a disadvantage in abrasive ground. Design improvements enabling these high-speed loaders to handle rock and ore in metal mines are increasing the field of application of these units.

Shuttle car installations are increasing in metal mines for drift work and gathering haulage. Diesel units are limited to areas with ample ventilation. Battery powered or cable-reel type cars have a limited operating range of about 600 ft.

Disadvantages of the shuttle car are: low travel speeds, high initial cost, poor traction in wet areas, and inability to travel on grades above 10% without slowing down or sacrificing load.

The diesel-electric unit illustrated is used for drift driving. It handles a 15-ton load without involving any delays for car switching. The diesel-electrics have the greatest possibilities, and eventually they will compete with truck haulage for long hauls, particularly when the exhaust problem is completely solved. This trend is a major one. In one metal mining district alone more than 25 coal-type loaders and 60 shuttle cars are in operation.

High-Speed Drifters

A leading manufacturer of mining machinery has designed and developed a machine that greatly reduces switching in drift headings. See accompanying drawing, which shows a high-speed combined jumbo and loading machine loading onto a unit which transfers the tonnage from a full round into a trip of mine cars.

In stopes, where broken ore must be delivered to a chute, there is a market for a self-powered, self-loading, compact, rubber-tired or fast moving half-track or "stope buggy."

Another possibility is a self-loading large scoop which might be installed to replace the open-type bucket on a tractor front-end loader. Here the scoop would pick up the load, and retain it while traveling to the dumping position.

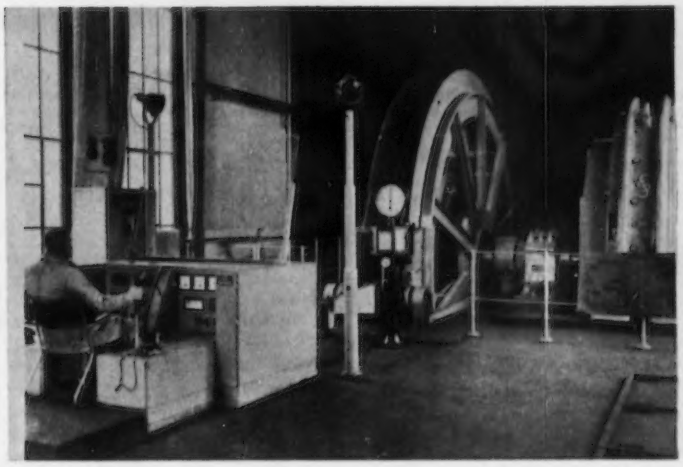
Continuous mining machines combining cutting, breaking, and removal of coal have proven so successful that some operators now rely on them for their entire production. It is reasonable to expect that additional design refinements can be made to adapt these machines to more resistant ores.

Improved rotary drilling techniques now make it possible to drill shales, gypsum, and moderately hard sandstones. Experiments at White Pine copper operations are encouraging. On installations where bits prove satisfactory, high drill footages have been obtained. Success of rotary drills in the pit also point up the possibility for increased application of rotary drilling underground. Once the problem of high-speed rotary drilling is solved for small holes, the size of holes and number of drill units can be increased to make it possible to remove an entire mining face in one operation.

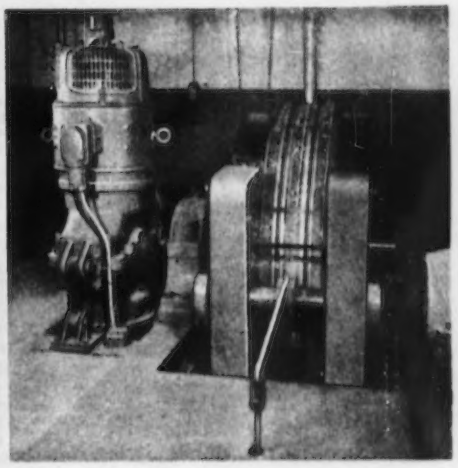
Problems to be Solved

1. Bits that will stand up for high-speed rotary drilling.
2. A positive depressant for irritating diesel exhaust gases.
3. Self-loading transport units for use as loading, gathering in stopes.
4. A method of breaking, removing, and loading hard ore in one operation—similar to continuous mining in coal and soft rocks.

In summary then, we wonder whether major changes will become a reality soon, and what the next thirty years will bring.



KOEPE HOIST installed in Germany is equipped with modern electrical controls. Drum dia is 6.2 m. Courtesy Demag Works.



TWIN-ROPE FRICTION DRIVE HOIST is powered by vertical motor. Courtesy ASEA, Sweden.

The Impact of Friction-Drive Hoisting

A. W. KNOERR, Editor

WORLDWIDE INTEREST in friction hoisting has resulted in a flood of technical articles, convention papers, etc., on the subject during the past two years.[1-7] This, despite the fact that friction hoisting is not new. It has been known and used with complete success in Europe for many years, and is the dominant type of installation in Sweden and Germany. In the U.S. a friction drive hoist has been in operation for years at the Silverton, Colo., property of Shenandoah-Dives. Commenting on this installation in 1947, Charles Chase, dean of Colorado mine operators and then manager of the property told the writer, "You know, we spend too much effort wearing out hoist ropes by winding them on and off drums. The principle purpose of a hoisting rope is to raise and lower loads in shafts." This comment proved to be prophetic, because today we note that at least five friction-drive hoists are scheduled for installation in the U.S., and two in Canada.

Foreign Surveys Pay

It is not the purpose of this article to imply that friction-drive hoisting will replace conventional drum hoisting entirely. The following two pages will make this clear. However, this sudden renewed interest in friction drive hoisting—almost as if it were a new discovery—offers an object lesson to the mining industry. It pays to look around to see what the other fellow is doing, not only in your own country, but in foreign nations as well.

A review of literature on friction drive hoisting reveals the following advantages:

Safety. The fact that multiple ropes can be used on friction-drive hoists is appealing to mine operators because it eliminates in part the hazard of a shaft disaster due to rope failure present in single-rope hoisting installations. Multiple-rope elevator installations in all tall buildings explain the fact that elevator disasters are so rare. The Ontario Dept. of Mines was so concerned over the necessity of improved hoisting safety, that it sent two delegates to examine hoisting procedures in Scandinavia and Continental Europe. The development of multi-rope units is largely responsible for the current interest in friction-drive hoisting.

Less rope wear. Friction drive hoists eliminate the fleet angle, cross-over points common to many multi-layer drum installations. Since friction-drive units can be installed directly over the shaft, they can do away with other rope-wear factors such as idler pulleys and occasional tension surges caused by rope sway between hoist house and headframe.

More compact, lighter equipment. Reduction of rope size in multi-rope installations permits a correspondingly smaller friction drum, since there is a definite allowable safe ratio between drum or sheave diameter and rope diameter. Smaller drums permit faster rotation to produce a specified hoisting speed. Higher drum speeds require less gear reduction between drive-motor and drum — an added advantage. Finally reduction of size and weight of the drum lowers the inertia factor that is involved in starting, stopping, and reversing the hoist.

Authoritative writers on friction-drive hoisting[3] have been helpful in pointing out advantages and disadvantages of the equipment. For instance, it has been pointed out that ropes cannot be lubricated, more rope is required, rope changes are more difficult, ropes must be replaced if the shaft is deepened, shafts must include space for counterweights, rope ends cannot be cut off for inspection.

The following two pages cover an interesting analysis of the electrical features of friction drive vs cylindrical drum installations by two electrical engineers.

1. "Friction Drive Type Mine Hoist" *E&MJ*, April 1954.
2. E. S. Little and C. M. Barrett. "Observations on Friction Hoists," Canadian Mining Journal, January 1954, and March 1954.
3. E. P. Pfleider, E. G. Malmlow, and F. Landau. "Friction Drive Mine Hoists—Recent Installations and Design Considerations" Mining Engineering, January 1955.
4. Guy N. Bjorge. "Friction Type (Koepe) Hoists" Mining Congress Journal, November 1954.
5. F. Landau. "Heavy Load Mine Hoist for Open-cast Operations at Kiruna, Sweden." The Mining Journal, October 15, 1954.
6. "Modern Winders for Bancroft Mines." Optima (Anglo American Corp. publication) 1954.
7. "The Friction Drive Hoists at Bodas Mine, Sweden." Booklet 7358E published by ASEA.

Comparison of Electrical Data for

	CASE I		CASE IV	
	Two counterweighted friction hoists	One double cylindrical drum hoist—clutched	Two counterweighted friction hoists	One double cylindrical drum hoist—clutched
Vertical shaft—depth	1225 ft	1225 ft	4335 ft	4335 ft
Tonnage per hour	1030 short tons	1030 short tons	307 short tons	307 short tons
Weight of material hoisted per trip	40,000 lb (lower empty skip)	40,000 lb (balanced operation)	24,000 lb (lower empty skip)	24,000 lb (balanced operation)
Weight of skip	30,000 lb	20,500 lb	14,400 lb	14,400 lb
Counterweight	50,000 lb	None	26,400 lb	None
Hoisting rope	(4) 1¾ in. dia (17,700 lb)	(1) 2¾ in. dia (10,900 lb)	(4)⅞ in. dia (21,300 lb)	(1) 1⅞ in. dia (24,300 lb)
Tail rope	17,700 lb	None	21,300 lb	None
Rope speed	1600 fpm	1600 fpm	2,300 fpm	2,300 fpm
Hoist	Pulley 10-ft dia	Drums 14-ft dia	Pulley 9-ft—10½ in. dia	Drum 12-ft dia
Inertia of hoist (drums, gears and sheaves)	1,000,000 lb-ft²	5,700,000 lb-ft²	1,870,000 lb-ft²	5,006,000 lb-ft²
Time: Acceleration	14 sec	14 sec	15 sec	15 sec
Full speed	31.9 sec	31.9 sec	100.5 sec	100.5 sec
Deceleration	14 sec	14 sec	10 sec	10 sec
Rest	10 sec	10 sec	15 sec	15 sec
Hoist motor speed	500 rpm	400 rpm	690 rpm	600 rpm
RMS duty hp	2780 (2 at 1390 ea.)	2415	2684 (2 at 1342 ea.)	2710
Power consumed hoisting normal load, kwh	31.2	26	69.3	58.2
Overall operating efficiency, %	59.1	70.8	56.6	67.3
15 min and 30 min demands kw	1612	1340	1775	1492
HP peak-hoist motor	3849	3520	4667	5341
Approx. relative cost of electric drives (%)	133	100	118	100
Weights moving in shaft	270,800	91,900	190,800	77,100
Weights to be accelerated	350,800	219,100	344,800	240,500

Electrical Aspects of Friction

A. HUELSMAN
Application Engineer
and
R. B. MOORE
Manager Mining
Industrial Engineering Section
General Electric Company

THIS PAPER has been prepared to assist mine operators in appraising the relative merits of friction-type hoists as compared with cylindrical drum hoists. A complete analysis requires study of:

1. First cost of electric drive, electrical operating costs, power consumption and demand.

2. First cost of mechanical equipment, operating advantages and disadvantages, and operating costs.

3. Installation costs for mechanical and electrical equipment.

Since the authors are not affiliated with any company supplying mechanical hoist equipment, this article presents a professional analysis of electric drives only.

Two basic types of installations are covered:

Type 1. Electric drives for multi-level mines where two counterweighted friction hoists would be used in place of one double cylindrical-drum hoist with clutched drums.

Type 2. Electric drives for single-level mines where one balanced friction hoist is compared with a single, divided, cylindrical drum hoist, or double cylindrical drum hoist, whichever is more practical.

Studies are based on specific hoisting duties, hoisting of identical tonnages for each mine. In all cases, dc Ward-Leonard drives with automatic controls are applied to provide a uniform base for hoist studies.

Multi-Level Mines

Under Type 1, four cases were studied. Two are shown in outline form in the above table. In Case I the hoist is in proposed stage with mechanical equipment arranged by a hoist builder for both friction and cylindrical drum type hoists. In Case IV the double cylindrical drum hoist is installed and operating. Operating data for the two counter balanced friction hoists were selected to perform on an equivalent duty.

Results of calculations. The following observations can be made on the basis of the four cases studied:

1. The two friction hoists will consume more power when lifting a specified weight of material for all four cases.

2. The demand as generally understood (for 15 or 30 min) is higher for friction hoists in all four cases.

3. Maximum momentary or instantaneous peak demand for friction hoists is higher than it is for one cylindrical drum hoist in Cases I, II, and III. In Case IV, involving a deep mine, instantaneous peak demand is greater for the cylindrical drum equipment.

4. Overall operating efficiency of two friction hoists is considerably less than that for one cylindrical drum unit.

5. First cost of electric drives for

Friction and Cylindrical Drum Hoists

	CASE IA		CASE IVA	
	One balanced friction hoist	One balanced single divided cylindrical drum hoist	One balanced friction hoist	One balanced single divide Clyindrical drum hoist
Vertical shaft—depth	1225 ft	1225 ft	4335 ft	4335 ft
Tonnage per hour	1030 short tons	1030 short tons	307 short tons	307 short tons
Weight of material hoisted per trip	40,000 lb	40,000 lb	24,000 lb (balanced operation)	24,000 lb (balanced operation)
Weight of skip	50,000 lb	20,500 lb	24,000 lb	14,400 lb
Hoisting rope	(4) 1⅝ in. dia (20,750 lb)	(1) 2¼ in. dia (10,900 lb)	(4) 1 in. dia (27,750 lb)	(1) 1¾ in. dia (24,300 lb)
Tail rope	20,750 lb	None	27,750 lb	None
Rope speed	1600 fpm	1600 fpm	2300 fpm	2300 fpm
Hoist	Pulley 10-ft dia	Drum 14-ft dia	Pulley 9-ft, 10½ in. dia	Drum 12-ft dia
Inertia of hoist (drums, gears and sheaves)	1,000,000 lb-ft²	4,500,000 lb-ft²	1,870,000 lb-ft²	5,006,000 lb-ft²
Time: Acceleration	14 sec	14 sec	15 sec	15 sec
Full speed	31.9 sec	31.9 sec	100.5 sec	100.5 sec
Deceleration	14 sec	14 sec	10 sec	10 sec
Rest	10 sec	10 sec	15 sec	15 sec
Hoist motor speed	500 rpm	400 rpm	690 rpm	600 rpm
RMS duty hp	2470	2410	2230	2710
Power consumed hoisting normal load, kwh.	27.8	26.2	60.4	58.2
Overall operating efficiency, %	66.4	70.5	65	67.3
15 min and 30 min demands kw	1433	1348	1550	1492
HP peak-hoist motor	3239	3462	3564	5341
Approx. relative cost of electric drives (%)	100	101	100	113
Total weights moving in shaft	181,500	91,900	117,500	77,100
Total weight to be accelerated	221,500	194,800	194,500	240,500

vs Drum Hoists

two friction hoists is 18 to 66% higher in price than the drive for one cylindrical drum hoist.

Single-Level Mines

In the following study of single-level mines, the multi-level counterweight friction hoist data were modified for single-level, balanced operation. This involved a change in skip weight, rope size, and elimination of the counterweight.

Double drum hoists were modified for single-level operation by changing to single-divided drums for mines having a depth of 2500 ft or less. A single-divided drum would be impractical for a single-level mine with a depth of 4,335 ft. Hence the electric study for the hoist drive for this mine was based on the use of a balanced friction hoist, or a double cylindrical drum hoist.

In the cases shown Case IA is a modification of Case I for single-level operation. Case IVA is a modification of Case IV for single-level operation.

Summary of Findings

Similar studies made for Case II and Case III are not presented here. However, calculations for the four modified cases are summarized in part as follows:

1. Power consumption and demand for the friction hoists are higher in all four cases. This is due principally to the fact that friction hoists have more weight moving in the shaft and therefore more friction loss than will drum hoists. Skip and rope weights for balanced friction hoists are higher than for corresponding weights for balanced drum hoists in all four cases. Higher skip and rope weights are required for friction hoists to prevent slippage; and calculations are based upon weights necessary to prevent slippage.

2. Momentary or instantaneous peak demand is higher for drum hoists in all cases.

3. Since power consumption is greater, overall efficiency is poorer for friction hoists.

4. First cost of electric drives will be practically the same for both types of hoisting systems.

Conclusions

Of the eight cases analyzed with respect to electrical drives only Case I, II, III, IV, IA, IIA, and IIIA favored the use of cylindrical drum hoists. Case IVA favored the use of a friction hoist.

It appears that the use of friction hoists would be preferable from the electric viewpoint for:

1. Very deep single-level mines (balanced operation) where the weights of hoist ropes are large, thus permitting the use of a lighter weight skip.

2. For hoisting systems which employ cages and cars for lifting materials. In this case the heavy weights of cages and cars prevent rope slippage.

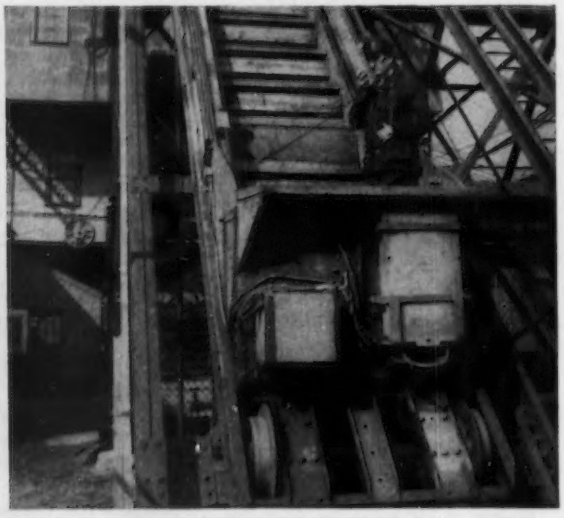
Since no attempt has been made to factor in the mechanical equipment or installation, it is pointed out emphatically that such an analysis should be made to supplement this electrical analysis before final conclusions are drawn.

(Editor's Note: The authors have prepared similar information in much greater detail for all cases cited here, for presentation at the American Institution of Mining Engineers Annual Convention, Chicago, Ill., Feb. 15, 1955.)

ON TOP. Hoisting engineer Floyd Hardy at Franklin mine doesn't have to guess whether men are on or off the cage.

BELOW. Construction worker, Leonard Johnstone, tells hoistman to "Take her away!" Note loudspeaker mounted above.

ON TOP. Hoisting engineer Joseph Hampton, Friedensville, Pa., waits for cager's instruction via HoistPhone installation.



ON THE WAY DOWN. A. G. Watt, mine foreman, Palmer shaft, at Franklin operations says "O.K. I'm on. Cut the rope!"

Shaft Safety Through Communications

SPEED, SAFETY, and smooth operation are the objectives of a good modern hoisting operation—and these objectives can be met through the installation of voice communication systems such as these HoistPhones at New Jersey Zinc Co.'s Franklin and Sterling mines in Sussex County, N.J. and at Friedensville, Pa.

Safety is assured because the hoist operator knows exactly what is going on—he doesn't have to guess whether men are moving on or off the cage when he pulls the controls. In belldinging hoist operations the hoistman has to be a cross between a mind reader and a telegraph operator. With voice communication systems, however, he knows where the men are, where they want to go, and can even change the cage destination if the cage tender changes his mind. If the cage has to be lowered or raised by inches to assist in some tricky unloading or loading problem, the cage can be "voice-guided" almost as smoothly as if the cager had the electric hoist controls under his own finger tips.

The units shown above were supplied by Mine Safety Appliances Co. They operate on a frequency-modulated (FM) carrier wave of 115 kilocycles. Variable volume control assures complete audibility under all circumstances.

How to Plan and Develop An Open-Pit Mine

GEORGE HUSEMAN
Mine Engineer*

DEVELOPMENT OF KAISER STEEL CORP.'s Eagle Mountain mines, Southern California, is described in this article to show the exact steps required to plan and mine an orebody by open-pit methods. Two orebodies are included in the property, the Bald Eagle mine, and the North-South pit. Principal emphasis will be given to the Bald Eagle mine because mining has advanced to such a stage as to permit the reader to check results achieved against original estimates and plans. Production at these mines increased from 60,000 tons per month in 1948 to 180,000 tons per month in 1953.

Here were some of the overall problems which confronted the pit planners in 1948:

1. Mine production would have to be flexible to meet varying ore demands.

2. Work would start on several benches in either waste or ore, whichever fulfilled production requirements.

3. Blending of ore to meet certain grades would be necessary.

4. Waste removal would have to be planned economically and advantageously.

5. Roads would have to be spotted where they would least interfere with mining but still allow shortest hauls.

6. A low waste-to-ore ratio would have to be set to cut overall mining costs per ton.

The following information had to be forthcoming before pit planning could start.

1. Location and shape of pit floors. (not easy to determine because mining would have to start 400 to 500 ft above anticipated floors).

2. Much detailed exploration work showing position of ore and waste.

3. Location and strike and dip of faults and dikes.

4. Attitude of ore beds and how they would stand when sloped off for pits.

5. The amount of ore and waste on each bench.

U. S. Bureau of Mines and the U. S. Geological Survey under a 1941-42 Strategic Minerals program had mapped and drilled both orebodies in a preliminary survey. Completed exploration by Kaiser Steel revealed one orebody containing some 5-million tons (Bald Eagle pit), and another, 51-million tons (North-South pit).

The Bald Eagle, our first experience, was a tough one on which to try fancy ideas. See plan and sections.

Ore structure dipped normally into a hill at 55 to 65 deg. One end of the contemplated pit sloped gradually downward over 2,000 ft, the other end was uncertain pending further exploration. Faulting was extensive in two directions, and to make matters worse, over half the total length to be mined was a fault block that jutted obliquely off normal strike and was sure to contain surprises. Dikes, plugging faults, and fracture zones wandered about uncertainly. Also the orebody dipped northward into property not then owned by Kaiser Steel Corp.

Thus it was necessary to fit a pit into an oblique triangle some 1400 ft in length along the north property line, and 800 ft in length along the east side adjoining the railroad car storage tracks. The orebody footwall on the southerly side was cut and offset by several large faults. This pit now nearing completion has turned out very well, developed according to the mining plan drawn in 1948, partly because the planners were rewarded with some good breaks.

Importance of Controls

The first job was establishing good controls for mining plans. The area to be explored was covered by a triangulation net tied to a U.S. Coast and Geodetic Survey nearby. This was an excellent starting point. We used two nets. A major net had a maximum error of 10 sec per triangle which made an error of less than .05 ft per triangle leg.

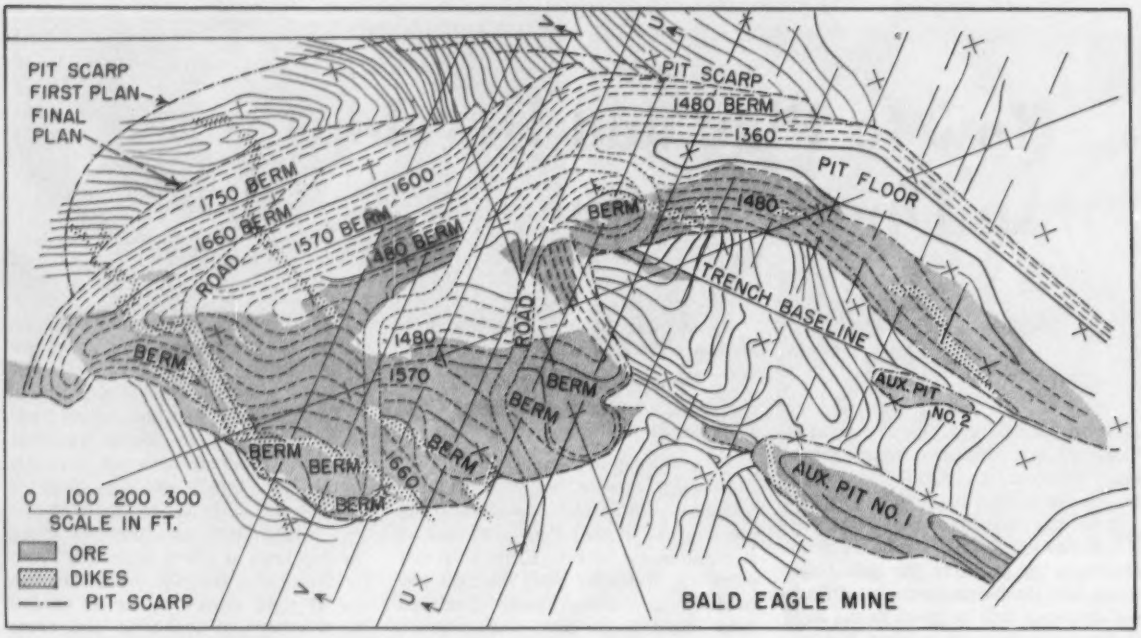
The minor net, less accurate, was tied to the major net and covered immediate vicinity to which baselines were tied. Baselines were run as nearly parallel to orebody strike as could be determined, with offsets where necessary. Hubs were carefully set along the baselines at 100-ft intervals. From baseline hubs, traverse lines were run out at right angles as far as needed for coverage of orebodies and areas that might be within pit outlines. Each traverse was closed and stakes numbered so they could again be occupied for taking geology, topography, and later for locating core drill holes and last, for making road locations, setting pit outline flags, and laying out bench data.

Base lines are very important. On the surface they served as a line on which traverses began and ended. On sections, geological data, core drill holes, benches, berms, pit outline, etc., were located by scaling from the base line.

Significant Geologic Details

After control was established, topography and geology were taken, usually together. Eagle Mountain ore occurs in what was originally two calcareous beds. The upper or North bed lying 50 to 250 ft discordantly over the lower or South bed. Beds dip northward and are remains of the north limb of an anticline striking east-west. Roughly, lithology goes like this: Under the 60 to 80 ft lower ore bed is a feldspathic quartzite 15 to 100 ft wide; then over the ore bed lie variations of schistose quartzite 50 to 250 ft wide which contain pre-mineral and post-mineral dikes. The upper ore bed is 90 to 400 ft wide on the surface, followed by lime silicates, quartzites and monzonites, all more or less mixed, badly faulted and intruded by dikes, dike masses and sills. Ore structure distance covering the pit areas is about 8200 ft long. Bald Eagle pit covers 2200 ft and North-South pit

* Formerly with Kaiser Steel Corp.



Key Points in Planning the Bald Eagle Pit

This project started with the establishment of accurate survey controls. Next geology was worked out in great detail. The precise location and position of dikes, faults, ore, and waste is the basis of all good pit planning. Then, after accurate cross sections had been prepared, the pit planners proceeded to establish the floor of the future pit, working out the height and slope of the benches, and finally estimating the volume and tonnage of ore and waste to be removed. This was all done on paper on a trial basis. If the ore-to-waste ratio indicated that the pit production would be unprofitable, the profile of the pit cross section had to be shifted. Note for instance in the pit cross sections how the pit floor and pit slope had to be changed,

5300 ft, with a large wash between them. Ore is a hematite-magnetite combination containing small amounts of limonite and pyrite.

Bald Eagle pit takes in the lower bed only, since the upper bed in this vicinity had almost completely eroded. Surveys on Bald Eagle covered a strip about 2,400 ft long and 1,000 ft wide. This included feldspathic quartzite in footwall, the ore zone, and the remaining quartzite over the ore. Where it was necessary to go farther into foot or hanging wall along faults, the area was extended.

Faults Must be Located

Working out faults properly was the toughest part of planning. Dips, strikes, relationship of one fault to another, effects on orebodies where they have been cut, ore displacements, and effect that a fault will have on pit walls are necessary information. Fortunately, at Eagle Mountain, principal faults are steep-dipping and generally normal. Two fault patterns exist. One series cuts the beds at right angles; the other runs parallel or obliquely across the beds. Neither displaces more than 300 ft vertically. Fault strikes were plotted on topographic-geologic maps and dips calculated by tangents where possible. Where surface conditions precluded accurate calculations, core-drill holes were driven on important faults to ascertain inclination and strike. Feldspathic quartzite was often used as a marker to solve fault problems. A few feet of it encountered in a drill hole simplified location of displaced structure.

Partial details of the geology of the larger North-South pit are shown in an accompanying cross-section.

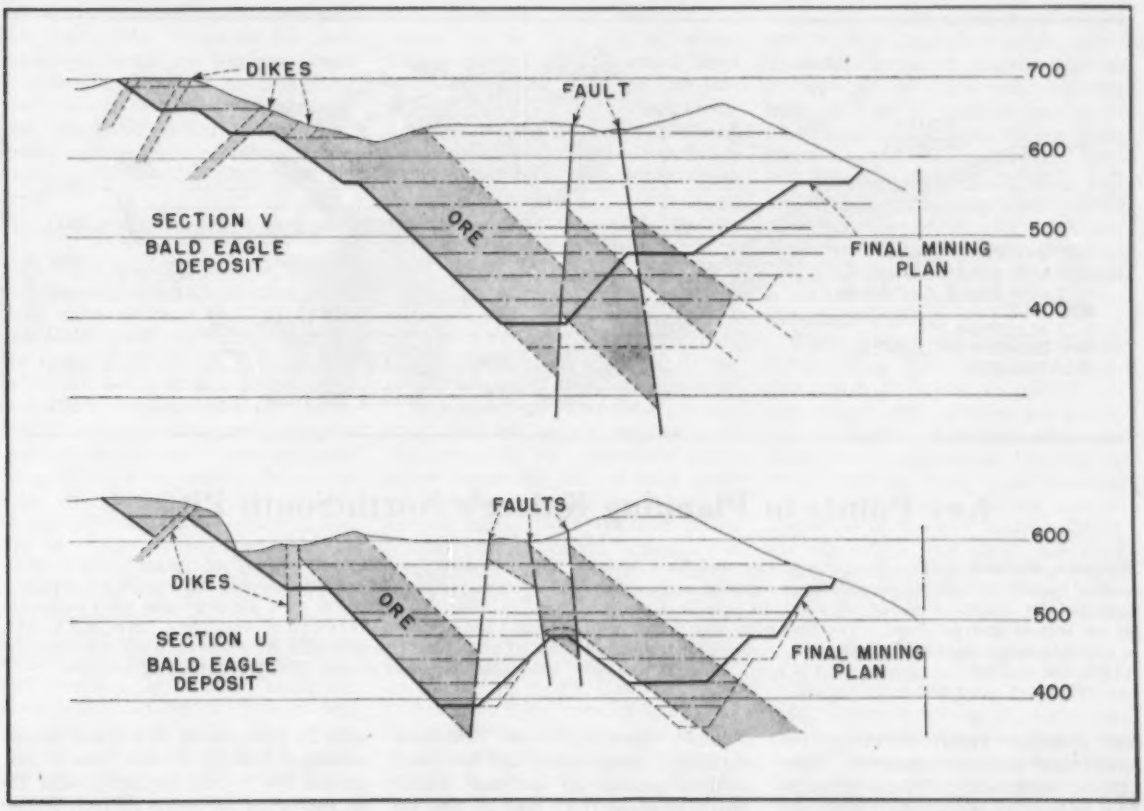
Exploration

With topography and geology completed, surface maps and sections for each 100 ft interval were made. On each, all available data was shown including ore, dips, faults, dikes, etc. Proposed core-drill holes were tentatively plotted on both plans and sections and locations for holes spotted on the surface for drilling. Core drilling on Bald Eagle totalled 5,337 ft, which was not enough for an ore structure of 2,000 ft chewed up by faults. Time was a limiting factor there.

How Holes Were Spotted

Holes were not always drilled as proposed on sections. If nearby holes showed up unexpected changes such as unknown faults cutting off ore, unlooked for ore blocks materializing, or low-grade ore where better ore was expected, proposed holes were often changed or not drilled at all. Drilling was confined to feeling out fault blocks and extending ore strike east and west from Bureau of Mines exploration.

Procedure on both orebodies was much the same for control, mapping, drilling and drawing pit plans, with one exception. On the North-South orebodies area, a magnetometer survey was made covering 5300 ft or ore structure containing 3500 sets. Some 2500 sets were made on ground having obscure or no visible outcrops in which considerable faulting had taken place. From the surface to a depth of about 150 ft, subsequent drilling proved magnetometer work highly de-



sacrificing some iron ore to cut down amount of waste to be removed. Note also in the pit plan at left, how the pit scarp in the upper left had to be moved in on the final open pit plan. The final profile permitted economic extraction.

pendable. When in doubt about drilling questionable areas for ore, reference was made to the magnetometer survey. Plus 1500 gammas were used as a "go-ahead" for ore and minus 1500 gammas when outlining waste blocks within ore zones. E. L. Stephenson, consulting geophysicist, who made the magnetometer survey, furnished KSC profiles for each section and an overall contour map using 1000 gamma intervals.

Waste Must be Delimited

It is fully as important to know extent, location and structural position of waste within what may be a pit, as it is to know ore. If waste position is known, a pit plan can generally be drawn to exclude it. Of 60 holes drilled by KSC on North-South orebodies, about one-quarter were drilled partially or totally to delimit waste areas. Including USBM-USGS work, 26,183 ft were drilled in the North-South orebodies. On the upper orebody, which had a width of 90 to 400 ft, prior exploration covered 1600 ft along an oblong hill where ore outcropped prominently, and 2200 ft on the lower bed. KSC, in addition to exploring ore structure east and west from Bureau of Mines drilling, drilled the beds on the down dip under Bureau work. To get depth for this, a tunnel was driven parallel to and in the footwall of the North bed nearly as could be determined and some 400 ft below the apex.

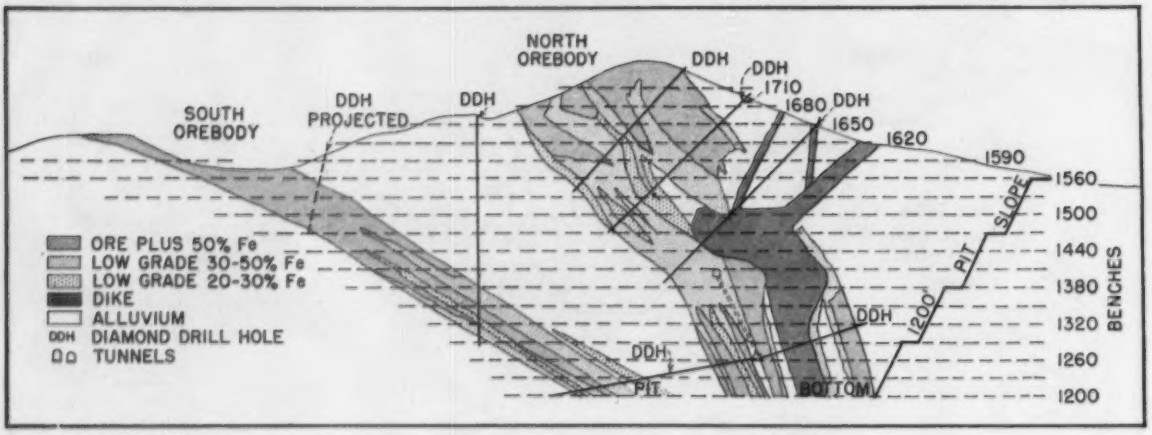
Mining Plans

mined and some 400 ft below the sections, the sections showing footwall, hanging walls, dikes, sills, faults, fault blocks, drill holes, ore grades and elevations were ready for drawing a mining plan. Benches were to be 30 ft in depth and pit slope on the hanging wall side ½ horizontal to 1 vertical with a berm 30 ft wide (each third bench for safety as a rock catcher). Overall slope was about 50 deg. Elevations of pit floors and problems due to a steep footwall were worked out. First adjacent sections were studied to determine how much ore of a particular grade could be dropped on one, two, or three sections at some point to eliminate waste elsewhere. Next we had to determine, if this was done, whether the mining plan had objectionable features such as sharp curves or walls that would not stand. How would the footwall look where faulted ore blocks offset into it? Could the faulted ore be mined successfully?

First consideration was to mine all available ore by removing as little waste as possible. This meant knowing closely where contacts between ore and waste lay. Next step was to put pit slopes and berms on the hanging wall side of sections using a tentative pit floor based on mineable grade ore, but avoiding big differences in floor elevations. Normal ore dip, with but few exceptions such as in faulted areas, was gentle enough so that natural dip could be used for pit slope on the footwall side of pits.

Projections Aid Plannnig

After pit slopes and berms were put on sections, a horizontal projection was made. This was the tentative mining plan. Horizontal projections tell much that is not revealed in sections.



Key Points in Planning Kaiser's North-South Pit

Extensive diamond drilling from the surface and from underground tunnels assured the pit planners a complete and accurate geologic and structural picture on which to base final position of pit bottom and pit slope. The first plan was drawn with a pit bottom at the 1200 ft elevation, yielding an estimated 43,886,000 tons of ore assaying 51.1% iron. Later it was decided to drop the bottom at one end of the pit to the 1110 ft elevation, yielding an estimated 51,094,000 tons of ore assaying 50.7% iron. To make this shift, the ore-waste ratio increased from 1 ton of ore to .344 cu yd of waste, to 1 ton of ore to .385 cu yd of waste. The increased ore-waste ratio did not preclude profitable extraction of ore. This pit contains 21 benches.

For instance, bench clearances between sections, existence of acute curves, workability of fault areas in foot or hanging walls are all apparent; also possibilities of working pit floors on different elevations efficiently. Generally, first projections needed much "ironing" out, sharp curves reduced, benches rearranged on curves, footwalls cut for slope so they would stand where fault blocks of ore cut into them deeply, etc. Sometimes several projections of difficult portions of the pit had to be made because original projections would be impractical. When transferring these changes back to sections, additional waste would be added and ore lost. If these additions and losses seriously affected waste ratio for those areas, changes would be made. Sometimes many thousand tons of ore had to be dropped to reduce waste quantities. In other cases, pit floors had to be lowered or raised to obtain satisfactory results.

Eliminating Flaws in Plans

After all apparent flaws had been corrected such as slopes and access to working areas on each bench for whatever size shovel was to be used, sections were made to conform. Total areas on each section within the pit were then planimetered, high grade, low grade, and waste on each bench done separately. Final figures then gave the ore-waste ratio.

Bench quantities were calculated separately, using trench and core drill samples plotted on sections. Where grades changed from hole to hole on benches, the "influence" or proximity of one hole to another was made by extending each about halfway. Holes were corrected for true width according to their inclination. The upper orebody has an average dip of 47 deg, so a hole cutting ore 100 ft at right angles to it would have a value of 100 times its adjusted assay value for whatever grade, or grades, it passed through. A hole drilled on the dip 100 ft would have a value of 15 times its adjusted assay.

As angles changed, values of holes changed. The various holes that penetrated or partially penetrated a bench were used for arriving at overall grades; the more holes, the greater the accuracy. When it can be used, this method of grading ore by rules eliminates the human factor of assigning assay values to blocks, which often tends toward conservative or generous estimates.

Planimeters Prove Useful

Polar planimeters were used to determine section areas. When properly adjusted and kept that way, we found these instruments accurate and fast. To be used with them, tonnage tables were made for each grade. A square inch on 60-scale sections would represent 24,730 tons of first grade ore if extended 100 ft, 49,460 tons if extended 200 ft, etc. Beginning with 20 ft, the tables are made in 10-ft intervals up to 200 ft, the maximum distance between sections. After benches were calculated showing tons of first grade, second grade, and cubic yards of waste, they were adjusted to give pit totals.

Ore-Waste Ratio is Critical

If ratio of ore to waste was not acceptable to management after a pit was completed, slopes and possibly the pit floor were changed. At Bald Eagle pit, the first mining plan made showed 1 ton of ore (first grade) to .410 cu yd of waste. Management objected to this high waste ratio and was willing to sacrifice ore for a reduction. Another mining plan was made. This cut ore tonnage by 1,018,000 tons but eliminated 1,501,000 cu yd of waste. It was acceptable. There were 14 benches, highest 1750 and lowest 1360 ft elevation in this pit. Final figures were 5,070,000 tons of plus 50% Fe to 1,652,000 cu yd of waste or an ore-waste ratio of 1 ton ore to .326 cu yd of waste. This did not include 1,585,000 tons of low grade. Trimming, scaling and footwall waste for passage on lower benches made a final ratio of 1 to .345. At the west end of Bald Eagle Pit, the footwall stood at a dangerous 55 to 65 deg. When ratio

was changed, dropping over one million tons of ore, much of this area containing poorer ore was abandoned by retreating from 50 to 130 ft on each bench as they were worked down. This precluded taking other safety means such as sloping footwall back, which would have been necessary.

Planning the North-South Pit

In some respects the North-South pit plan, containing approximately ten times more ore than Bald Eagle pit, was easier to draw. Orebodies lying one over the other were to be worked as one pit. Before drilling began it was decided that exploration should reach 1200 ft elevation along the strike except on the east end where prospects for good ore were greater. Here some holes were bottomed below 1100 ft. If waste-to-ore ratio at those depths was too high, we reasoned that the pit floor could be raised until a satisfactory ratio was obtained. Working on that assumption, the plan was begun on 1200-ft elevation. At this pit there was no problem about the footwall standing. It followed along the lower bed which dipped 30 to 40 deg. On the hanging wall side where "fingering" reduced width of upper orebody greatly at depth, some places cutting it out completely, it was a simple matter of making a plan conform with exploration results. Eliminating these barren zones was done by widening berms from a normal 30 ft to over 200 ft where needed.

The west end of North-South pit has more curves than a mountain railroad. That is caused by faulting and failure of solutions to replace much of the upper bed at depth on this end. In these areas, when it was a question of whether or not to include faulted or isolated ore segments in mining plans, decision rested on a commercial basis as to how much waste could be profitably moved to get to the ore. This took considerable extra calculating, but eliminated guessing.

The first plan made, using 1200 ft elevation for all but the west end, which was higher, showed pit contents to be 43,886,000 tons of ore assaying 51.1% Fe for which 15,096,000 cu yd of waste would have to be moved. This made an ore-waste ratio of 1 ton to .344 cu yd. Later it was decided to include the ore above 1110 ft elevation on the east end. This increased total ore to 51,094,000 tons, assaying 50.7% Fe for which 19,672,000 cu yd of waste would have to be moved, or an ore-waste ratio of 1 to .385. There are 21 benches in this pit, highest 1710, lowest 1110 ft elevation.

Most ore in both pits lay above general ground level. Ground level varied from 1150 ft on the east end of North-South Pit to 1400 ft elevation between the pits where railroad loadouts are located and a beneficiating plant has been built. Fully three-quarters of the ore in the pits is, or was, above general ground level to permit down-grade hauling.

Carrying Out Mining Plans

To put a mining plan into operation, it is transferred from maps to the ground as needed. This is easily done by triangulation. Triangulation stations were set on pit perimeters of high ground to be visible from many places within the pits. A third point was set where needed in the pit to form a triangle with the two points outside. For pit control, where 0.3 ft is sufficiently close, only two triangulation stations are occupied for a triangle.

Triangles were computed at the office and points plotted by coordinates on mining plans for transfer to the ground. Bench toe lines, pit scarps and berms were laid out as needed. Elevation controls are set with an engineer's level each 30 ft vertically or less, and marked, usually with a tin strip on power poles within pits so they can be used for checking elevation by hand levels as benches are worked.

How Practical Are Mining Plans?

Since Bald Eagle pit is virtually worked out—we can appraise the results of drawing a mining plan for extracting such an orebody. Core recovery, as stated, was poor, and sludges far from reliable at times, yet ore shipments made to the blast furnaces in tonnage and grade were not far from calculated results. Mining costs were low for such a small pit and monthly ore requirements were maintained without much difficulty. Luck helped a few times by having uncharted ore blocks turn up when badly needed.

Of the 5,070,000 tons of plus 50% Fe calculated tonnage, 4,174,000 tons had been extracted by early 1954. In what was the original mining plan (the plan was extended to include ore-bearing ground later acquired by KSC adjacent to Bald Eagle pit), another 450,000 tons were expected on 1390 and 1360 benches, making a total of 4,714,000 tons, or 7% less than calculated. Adjusted average for plus 50% ore was 52.26% Fe as calculated. Shipments totaling 4,006,000 tons made to Fontana over 4½ years from Bald Eagle pit assayed 54.67% Fe, or gain of 4.6% over adjusted average. Loss in tonnage was probably due to raising grade. Of low-grade ore, calculated tonnage showed 1,585,000 tons. On 1540 bench, about half way mark on the tonnage after 794,000 tons assaying 43.4% Fe has been stockpiled, this grade was discontinued. How it would have checked out is not known. Presumably close to the calculated tonnage.

Waste volumes also turned out well. Where close check has been kept, down to 1450 bench, calculated volume vs removed volumes was within 3%. This did not include all waste. Some was removed along footwall for roads, and to make extra working space which the plan did not include. The slope of one-half horizontal to 1 vertical with a 30-ft berm each third bench on the hanging wall side was found satisfactory in most places.

No Fall-of-Rock Accidents

No accident occurred from falling rock, although scaling of slopes was discontinued about halfway down. The footwall side was more dangerous. Large slabs weighing up to 200 tons had formed on the footwall under the ore. These were held in place by nothing more secure than overlapping portions of similar slabs. When working along steeper sections of footwall, spotting holes and shooting had to be done carefully. At another place a fault block between two major faults might have caused trouble in wetter country or if operations in this pit had extended over a longer time. The block was tilted so its bedding planes were quite flat and lay roughly parallel to the hanging wall slope. From time to time chunks would slide off along the bedding planes into the pit. At one place in this tilted block sloughing quartzite plowed through a 30-ft berm. This example is cited to show the danger of laying out slopes where attitudes of beds are bad. Otherwise, no trouble was caused by the numerous faults.

Credit to Planners

Cooperating to make mining plans and planning exploration procedure with the writer were several on the Kaiser Steel Corp. mining staff:

K. P. Powell, superintendent of raw materials and his assistant, B. A. Binckley; J. G. Hansen, superintendent of Eagle Mountain mines and his assistant, J. D. Burgess.

Drilling and Blasting Data for Various Types

Type of Open Pit mine	Tons of ore and waste per day (Av., 1953)	Type of rock	Primary drills O-ore W-waste	Bits, size	Steel C-carbon A-alloy	Bench height ft	Depth of holes ft	Aver. drilling speed ft/hr	Holes drilled per round
1. Asbestos	O.. 7,200	Med. non-abr	LP (O & W)	5½" TC		75–125	Var	10	Var.
	W.. 4,050	Med. non-abr	LP (O & W)	4" TC			Var	18–25	
			MOB (O & W)	3" SU & TC	C		20 toe		
2. Asbestos	O.. 4,350	Med. non-abr	WAG (O & W)	2¾"-3 SU	A & C	50	35 vert	20	Var
	W.. 2,540	Med. non-abr	M-DR (O & W)	2¾-3" TC	A & C		20 toe		
3. Asbestos	O.. 2,630	Med. non-abr	WAG (O & W)	2½-3" SU & TC	C	40–50	40 vert	15	Var
	W.. 140	Med. non-abr	LP (O & W)	3½" TC	Spec. rod		20 toe	17½	
4. Asbestos	O.. 4,600	(O) Sft., non-abr	WAG (O)	2¾-3" SU	C	35' (O)	40 (O)	25 (O)	65 (O)
	W.. 400	(W) Hrd., abr	WAG (W)	2½-3" TC	A			12 (W)	
5. Iron Ore	O.. 7,200		CH (W)	9" and 6"	C	25–28 (W)	28–30	4.20 6" (W)	24 6" (W)
	W.. 21,200	Hrd.-Sft. abr						6.00 9" (W)	35 9" (W)
6. Iron Ore		Hrd.-Sft. abr-non-abr	CH (O)	9"	A & C	30 (O)	35 (O)	6–12	15 (O)
		Hrd.-Sft. abr-non-abr	WAG (O)	2-3" TC	A & C				
7. Iron Ore	O.. 8,000	Hrd.-Sft. abr	CH (O)	9"	A	15 (O)	20 (O)	2.5-20 (O)	Var
	W.. 15,000	Hrd.-Sft. abr	CH (W)	9"	A	30 (W)	36 (W)	5.5-9 (W)	
8. Iron Ore	O.. 3,550	Med. abr	CH (O)	9", 500 lb	C	25 (O)	30 (O)	7 (O)	50 (O)
	W.. 1,010								
9. Iron Ore	O.. 2,880	Very Hrd	CH (O)	9", 500 lb	C	60 (O)	65 (O)	1.9 (O)	12 (O)
	None								
10. Iron Ore	O.. 17,675	(O) Med., non-abr	CH, AUG (O)	6-9" CH	C	30–35 (O)	35–40 (O)	8 (O)	20 (O)
		(W) Hrd., abr	& WAG (O)	6" AUG				4 (W)	16 (W)
11. Copper	O.. ——	(O) Hrd., abr	CH (O)	9"	C	50 (O)	55 (O)	14 (O)	15 (O)
	W.. ——	(W) Med. Hrd., abr	CH (W)	9"	C			20 (W)	25 (W)
12. Copper	O.. 11,870	Med., abr	CH (O)	9"	C	45 (O)	51 (O)	10 (O)	10 (O)
	W.. 1,918	Med., abr	CH (W)	9"	C	45 (W)	51 (W)	10 (W)	10 (W)
13. Copper	O & W.. 42,000	(O) Med., abr	CH (O)	9"	C	50 (O)	57 (O)	10 (O)	10 (O)
		(W) Sft., abr	CH (W)	9"	C	50 (W)	57 (W)	10 (W)	10 (W)
14. Copper	O.. 3,500	Med.-Hrd., non-abr	CH (O)	7"	C	50 (O)	55 (O)	6 (O)	7 (O)
	W.. 14,000	Med.-Sft., non-abr	CH (W)	7"	C	50 (W)	55 (W)	8 (W)	15 (W)
15. Copper	O.. 13,000	Med. Sft., non-abr	CH (O)	9"	C	50 (O)	55 (O)	12 (O)	10 (O)
	W.. 30,000	Med. Sft., non-abr	CH (W)	9"	C	50 (W)	55 (W)	12 (W)	10 (W)
16. Copper	O.. 13,830	Hrd. Sft., abr	CH (O)	9"	A	50 (O)	57 (O)	8 (O)	10 (O)
	W.. 8,963	Med.-Sft., abr	CH (W)	9"	A	50 (W)	57 (W)	8 (W)	10 (W)
17. Copper	O.. None	——	CH (W)	9"	C	50 (W)	60 (W)	10.3 CH	30 (W)
(Stripping only)	W.. 61,471	(W) Med., abr	ROT (W)	7¾"	C			43 ROT	
18. Copper	O.. 29,526	Hrd., abr	CH (O)	12" CH (M)	A	40 (M)	53 (M)	6 (M)	15 (M)
	W.. 45,104	Hrd., abr	MOB, LP (O)	3" & 6" TC (F)	A	33 (F)	39 (F)	15 (F)	50 (F)
19. Copper	O.. 50,000	Med.	CH, ROT (O)	9–12" CH	C	50 (O)	60 (O)	10 (O)	60 (O)
	W.. 92,000	Med.		7⅞" ROT	C			10 (W)	60 (W)
20. Copper	——	(O) Med. non-abr	MOB (O)	2¾"-3" TD	A	50 (O, W)	Toe hole	42 (O)	14 (O)
	——	(W) Med. abr				70–80 (O, W)	28' toe hole	42 (W)	14 (W)
21. Copper	O.. 22,500	——	CH (O)	12"	C	43 (O)	51 (O)	Var	Var.
	W.. 42,000	——			C	43 (W)	51 (W)	Var	Var.
22. Magnesite	O.. 1,582	(O) Med.	ROT (O)	6¼"	C	40 (O)	47 (O)	12.5 (O)	30 (O)
	W.. 4,335	(W) Med Sft.	ROT (W)	6¼"	C	40 (W)	47 (W)	12.5 (W)	50 (W)
23. Barite	O.. 2,000	(O) Hrd Sft. non-abr	CH (O)	6"	C	Var	Var	Var	
	W.. 9,000	(W) Hrd Sft. abr	WAG (O)	2½" TC	C	Var	Var	Var	150 (O)
			AUG (O)	½ x ½ x 3" TC	C	Var	Var	Var	75 (O)
24. Ilmenite	O.. 3,000	(O) Med., abr	LP (O)	6 TC	A	40 (O)	44 (O)	11.1	40 (O)
	W.. 1,000	(W) Hrd., abr	LP (W)	6 TC	A	40 (W)	44 (W)	10.6	

Open-Pit Survey

Operating data compiled here is based upon a 1954 *E&MJ* survey of major open-pit mines in North America. Ore plus waste mined by these operations totals more than 1,000,000 tons per day.

General: O—ore; W—waste; O&W—ore and waste; Var—variable.

Type of rock: abr.—abrasive; Hrd.—hard; Med.—medium hard; Sft.—soft.

Primary drills: AUG—auger drills; CH—churn drills; LP—large percussion drills; MOB—mobile-type drills; ROT—rotary drills; WAG—wagon drills.

Bits: CH—churn drill bit; ROT—rotary bit; SU—single-use or throw-away type; TC—tungsten carbide, all types; TD—threaded detachable steel bit.

Steel: C—carbon steel; A—alloy steel.

Powder consumption; hard—in hard ground; soft—in soft ground.

Type powder: dry—in dry holes; wet—in wet holes; quar—quarry type powder; gel—gelatine type.

Secondary breaking method: D&B—drill and blast; DrB—drop-ball method; MC—mud capping or "pasters"; ShC—shaped charge.

Methods listed have been tried; those underlined are now being used.

Secondary drills: JH—jackhammer type; WAG—wagon drill; MOB—mobile-type drill.

Bits for secondary drilling: SU—single-use or throw-away types; TC—tungsten-carbide, all types; TD—threaded-detachable bits.

# of Metal and Nonmetallic Open Pit Mines

Type of Open Pit mine	Ft drilled per round	Tons broken per round	Powder consump. lb/ton	Type powder	Secondary breaking method	Secondary drills	Bits for secondary drilling	Remarks on spacing of holes
1. Asbestos	Var.	Var.	0.15 (O)	40%	D&B, DrB, ShC	JH	7/8-2" SU	(Spacing refers to distance between holes in same row. Second dimension is distance to toe, or between rows).
	Var.	Var.	0.15 (W)	40%				
2. Asbestos	Var.	Var.	0.14 (O)	40%	D&B	JH	1-1 1/2" SU	
	Var.	Var.	0.14 (W)	40%				
3. Asbestos	Var.	Var.	0.21 (O)	40%	D&B, ShC	JH	1 1/8" TC	
	Var.	Var.	0.21 (W)	40%				
4. Asbestos	2,600 (O)	10,000	0.14-0.25	40% &	D&B, MC	JH	1 3/4-1 1/2" SU	3 x 10-12 ft
		(O)		70%				12-15 ft to toe
5. Iron Ore	672	10,080	1.07 hard	40%	(None)			(6") 15 x 15 ft hrd
	1,050	16,800	0.20 soft	40%				(9") 20 x 20 ft soft
6. Iron Ore	525	6,000	0.40	70%	D&B	JH	1 3/4-2" TD	Single row 12 to 18 ft
7. Iron Ore	Var.	Var.		40% Winter	D&B, MC	JH	TC	18 x 18 ft
	Var.	Var.		25% Summer				20 ft to toe
8. Iron Ore	1,500	45,000	0.40		D&B, MC	JH	1 3/4" TC	25 x 20 ft
								20 ft to toe
9. Iron Ore	780	24,000	0.52		D&B, MC	JH	1 3/4" TC	20 x 22, 22 ft to toe
10. Iron Ore	700 (O)	7,200	0.45-0.7 (O)	—	MC, D&B, ShC	JH, WAG, MOB	1 3/4-3" TC	(O) 15 to 24 ft
	400 (W)	2,128	0.75-1.5 (W)	—			1 3/4-3" TD	(W) 12 to 18 ft
11. Copper	825	30,000	0.24 (O)	60% gel.	D&B	JH	1 3/4" SU	27 ft spacing
	1,500	55,000	0.22 (W)	60% gel.				18 ft to toe
12. Copper	514	33,000	0.227 (O)	60% gel. &	MC, D&B, ShC	JH	2 1/2" TD	24 ft spacing
	514	33,000	0.227 (W)	70% bag				42 ft to toe
13. Copper	570	67,500	0.13 (O)	5 lb.	MC, D&B	WAG	2 5/8" TD	25 ft spacing
	570	67,500	0.13 (W)	quar. bag				40 ft to toe
14. Copper	385	8,000	0.3 (O)		MC, D&B, ShC	JH, WAG	1 1/2-2 1/2" TD	(O) 20 x 12 ft
	825	24,000	0.2 (W)					(W) 15 x 15 ft
15. Copper	550	35,000	0.14 (O)	60 & 70%	MC, D&B	JH, WAG	1 1/2-1 7/8" SU	25 ft spacing
	550	35,000	0.14 (W)	gel.			1 1/2-3" TD	40 ft to toe
16. Copper	570	50,000	0.18 (O)		D&B, MC, ShC	JH	1 7/8" SU	20 ft spacing
	570	72,000	0.125 (W)					35 ft to toe
17 Copper (Stripping only)	1,800	64,800	0.23 (W)	70% (dry)	D&B, DrB	WAG, JH	1 3/4-2 5/8" TD	15 ft spacing
				60% (wet)			1 3/4-2 5/8" TC	30 ft to toe
18. Copper	795 (M)	62,500	0.24 (M)	60% quar.	MC, D&B, DrB	JH, MOB	1 3/8" TC	(12") 27 to 43 ft
	1,950 (F)	39,000	0.34 (F)	70% bag	ShC			(6") 14 to 16 ft
19. Copper	3,600	180,000	0.22 (O)	70% quar.	MC, ShC, D&B	JH, MOB	2-2 3/4" TC	24 ft
	3,600	180,000	0.22 (W)	60% gel.				36 ft to toe
20. Copper	336	33,000	0.87 (O)	65% gel.	MC, D&B	JH, MOB	1 1/2-2" SU	Var
	336	33,000	0.87 (W)					Var
21. Copper	Var.	Var		70% (dry)	D&B	WAG, JH	1 7/8-2 5/8" TD	25 ft
	Var.	Var.		60% gel (wet)				36 ft to toe
22. Magnesite	1,410	24,450	0.4 (O)	50% gel.	MC, D&B	JH	1 3/4" TD	16 ft spacing
	2,350	40,750	0.32 (W)	50% gel.	DrB, ShC			14 ft to toe
23. Barite	1,750 (O)	5,000 (O)	3.5	40 and	MC, D&B	—	—	Spacing, var
	1,250 (O)	5,000 (O)	3.5	50% gel.	ShC			
24. Ilmenite	1,760 (O)	43,500	0.278 (O)	50% gel.	MC, D&B	JH	3/4" TC	Spacing 16 ft
			0.34 (W)					Av, 14 ft to toe, between rows 12 & 14 ft

Additional notes pertaining to operations listed above.

1. Asbestos: Bench height varies from 75 to 125 ft. With Quarrymaster, 35-ft burden and 15-ft spacing is used for 102-ft down holes, one row only. On the toe, drill mobiles drill 40-ft toe and knee holes, and 40 to 60-ft breast holes.

With the Challenger unit, drilling 70-ft down holes, a burden of 12 ft, and a spacing of 10 ft is used. Two rows are drilled at a time. On the toe, 30-ft holes are drilled by drill mobiles.

4. Asbestos: No complete rounds are drilled in waste. Granite waste dikes are drilled and blasted as encountered.

5. Iron Ore: Ore does not require blasting. Waste consists of hard and soft taconite as indicated.

6. Iron Ore: Jackhammers and detachable bits are also used to drill out ore.

7. Iron Ore: Ore mined is 8,000 tons per month for 6-month season. Waste removed averages 15,500 tons per month for 12 months.

17. Copper: Stripping operation only.

18. Copper: Two types of ore are mined: (M) monzonite; and (F) fangiomerate.

20. Copper: Mobile type drill consists of a tractor, compressor, and shop-built drill mounting. Bench height varies from 50 to 80 ft. Medium banks (50 ft) are drilled with 24 to 28-ft toe holes only. High banks (70 to 80 ft) are drilled with 28-ft down holes, and 24 to 28-ft toe holes. All holes are sprung to hold powder charge at bottom.

22. Magnesite: Wagon drills are used to drill toe holes on 6-ft centers.

Chemical Metallurgy Solves Low-Grade, Complex Ore Problems

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RECENT DEVELOPMENTS in hydrometallurgy have materially increased the potential of this important metallurgical process for metal recovery, either as a primary or auxiliary method. The necessity for treating complex and lower grade ores, combined with higher metal prices, has stimulated successful research in two major fields of particular interest to the hydrometallurgist—roasting and leaching.

FluoSolids

Development of the fluidized-bed technique, exemplified by the Dorrco FluoSolids reactor, has made possible more precise control of temperature and gas composition during the roasting operation, thereby increasing the range of products which can be made amenable to leaching methods. Most important feature of this development is the improved potential for selective sulfatization of specific components of ores and concentrates, which while theoretically possible, had previously only attained partial success in commercial practice.

Applications for fluidized-bed roasting, successfully proven, or in the investigational stage, are for copper-zinc sulphides, zinc sulphides, copper-cobalt sulphides, copper sulphides, mixed copper sulphides and oxides, and arsenical gold and copper-gold ores. These applications are only mentioned briefly, as the subject is discussed in detail as a separate article in this issue.

Conventional hydrometallurgical methods for the recovery of metals were limited because the principal reactions were carried out at or below atmospheric pressures and boiling temperatures. An alternative to the previously available hydrometallurgical and pyrometallurgical processes for the recovery and refining of base metals has been provided by the introduction of the autoclave technique whereby pressurized gases at elevated temperatures and pressures speed up oxidation and reduction rates under precisely controlled conditions.

The oxidizing gas is oxygen which is commonly employed as compressed air, but oxygen or oxygen-enriched air may be substituted. For precipitation of the metals by gas reduction, hydrogen is used, but carbon monoxide or sulphur dioxide are possible alternatives. Metal powders produced by gas precipitation are of high purity, and direct conversion to marketable shapes by rolling, pressing, or extrusion without an intermediate melting step, is under investigation.

Pressure leaching and hydrogen reduction have been employed only in plant practice for the recovery of nickel, cobalt, and copper. Recent technical articles by F. A. Forward and associates have described investigations on the pressure leaching of uranium ores and the precipitation by hydrogen reduction of vanadium; and L. N. Allen Jr. has described the pressure leaching of manganese ores.

Treatment of metallic ores and concentrates by chemical methods at elevated pressures and temperatures is not new but recent research in this field has resulted in the discovery of a number of new processes. This research, pioneered by Chemical Construction Corp. and Sherritt Gordon Mines Ltd., has resulted in the completion of four commercial plants.

First Calera

First to start producing was the cobalt refinery of Calera Mining Co. which began operations in the late summer of 1952 at Garfield, Utah. Feed to that plant is a cobalt sulpharsenide (cobaltite) concentrate which assays 17-19% Co, 25% As, 30-32% S, 19-20% Fe, some silica and a small amount of Ni. The concentrate is slurried with water and pumped into the head end of a horizontal, brick-lined autoclave which is divided into six compartments. Each compartment is equipped with a mechanical agitator to keep the concentrate in a state of suspension.

The autoclave is sized to allow a residence time of three hours, and is maintained at a pressure of approximately 600 psi and a temperature in a range of 300 to 400 deg F. Because the concentrate is abrasive and the head unusually high, pump maintenance has given difficulties. A number of pumps have been used for this service and a novel displacement type recently developed seems to give the best results.

96-98% Extraction

Compressed air fed to the autoclave, oxidizes the sulphur in the concentrate to form H_2SO_4, the leaching agent for the cobalt and nickel values. Extractions of 96-98% are usual. When the concentrate reaches the sixth compartment it is discharged through a special valve to a flash tank. Steam and other gases, mainly nitrogen, are also discharged through a let-down valve to maintain the desired pressure. From the flash tank the pulp goes to filters, the cake being discarded and the filtrate, containing cobalt and nickel sulphates, is purified and neutralized with ammonia prior to reduction. A special feature of this operation is that the arsenic contained in the concentrate feed is converted to a virtually insoluble iron-arsenate during the leaching step which can then be discarded to waste without creating a danger hazard.

Reduction is a batch operation in a number of agitated autoclaves and is accomplished at elevated pressure and temperature by hydrogen, produced from propane at the property in a small gas reform unit.

Metal is reduced from the solution

as a fine powder which contains both cobalt and nickel. No attempt is made at this plant to separate the two metals since the alloy, as produced, is acceptable, after melting the powder to produce rondelles.

The plant was designed to produce ammonium sulphate as a by-product. For various reasons this part of the plant has not been operated to any extent, but it is planned for production in the future.

Capacity for which the plant was designed has not been attained. Chemical Construction Corp., who licensed, as well as designed and constructed the plant, took over its operation a year ago for a period of two years. Additional equipment is being installed to bring the plant capacity up to the desired level.

Then Sherritt Gordon

The Sherritt Gordon Mines Ltd. nickel refinery at Fort Saskatchewan, Alberta, Canada, went on stream in July 1954. This plant was designed to treat 80,000 tons of concentrate per annum by a completely new sequence of chemical metallurgical processes. Five years were devoted to development work on these processes and equipment in a series of pilot plants, in collaboration with Chemical Construction Corp., prior to final plant design. The feed treated in this plant is a nickel concentrate assaying 12-14% Ni, 1-2% Cu, 0.3-0.4% Co, and 28-34% S. The leaching method proposed by Professor Frank A. Forward using ammonia, air, and water under approximately 100 psi and a temperature of 170 to 180 deg F extracts better than 90% of the nickel. The leaching takes place in two sets of autoclaves.

Following the leaching steps the pulp is thickened and filtered and the filtrate, containing soluble nickel, copper, and cobalt ammines, is purified prior to reduction. Nickel is reduced with hydrogen under pressure in stirred autoclaves. The solution, after reduction, is stripped of any remaining nickel and its cobalt and then sent to the ammonium sulphate plant for crystallization. Cobalt metal and copper concentrate will also be produced as by-products.

The refinery produces its own ammonia and hydrogen from natural gas. It also produces about half its power, as well as its steam requirements, from the same source.

The latest reports on the Sherritt Gordon refinery are most encouraging. Production has kept pace with the schedule and it seems likely that the capacity of the plant will exceed its design capacity. A series of papers on the Sherritt Gordon enterprise are to be given at the April meeting of the Canadian Institute of Mining and Metallurgy, which will give an up-to-date record of this new plant.

Whitaker Treats Scrap

The third plant that falls into the category of chemical metallurgy, now just getting under way in North Kansas City, Mo., is that of the Whitaker Metals Corp. The raw material for this plant is zinc-contaminated copper scrap, from which is produced copper powder.

Still another leaching method is used at this plant—ammonium carbonate, practically at atmospheric pressure. The solution after purification is again reduced by hydrogen in a stirred autoclave to produce a copper powder of unusually good characteristics for the copper powder market. The plant is the minimum commercial size and is now turning out several thousand pounds of powder per day and its capacity can be doubled with a modest addition of equipment.

Invention of the copper scrap process was made by engineers of Chemical Construction Corp. and it was then developed in their laboratories in collaboration with Chemetals Corp. who have obtained licensing rights in certain countries. Several companies in this country and abroad have expressed interest in building copper scrap plants. In addition to the copper powder market it is expected that the powder will find use as a feed to a rolling process, also licensed by Chemetals Corp., which is expected to produce rod and strip of high quality.

Fredericktown Starting Up

The fourth plant, now undergoing trial runs, is the Fredericktown, Mo., plant of National Lead Co. A complex cobalt-nickel-copper sulphide concentrate is being treated by a process somewhat similar to that employed by Calera. The concentrates are treataed at elevated temperature and pressures in stirred autoclaves. Acid formed by the action of air on the sulphides leaches the three metal values which are subsequently to be produced as separate metal products. Since the quantities of the three metals in the concentrates are approximately the same, each must be substantially recovered as a separate product. This plant is still in the starting-up stage, but good progress has been made in solving its special problems.

And Now Freeport

Freeport Sulphur Co. has engaged Chemical Construction Corp. to engineer a 50 tpd pilot plant to be located in Louisiana which will be used to demonstrate a process worked out to recover nickel and cobalt values from laterite ores discovered at Moa Bay in Cuba. A substantial research program was carried out prior to a decision as to the process to be used. It is expected that this pilot plant will be in operation next fall.

It is still too early to evaluate these various processes successfully since operating costs are not available, nor overall efficiencies. Furthermore, like other new developments in metallurgy, the processes and equipment first used can be expected to change and improve over the years to obtain lower cost and better recoveries. Certainly, there is a big field for improvement in the equipment used and its maintenance. Equipment that can stand the rigors of pressure, temperature, abrasive pulps and corrosive liquids has been developed and is used with more or less satisfactory service, but changes have already been made or are contemplated.

It would be well to point out the variety of the processes recently put into operation or proposed for specific ores. Each of the plants mentioned employs a process tailored to its problems. The complexity of natural ores and concentrates and the variables in the economics affecting each installation will require the development of a special flow scheme to produce optimum results. Fortunately, there are now a diversity of these new methods to encourage a new examination of these "chemical metallurgical" methods when seeking ways to improve on present practice in this field.

Ion exchange as a hydrometallurgical process has many possibilities which are awaiting development through more widespread investigation of these "chemical metallurgical" waste solutions of various metals, but there is a growing interest for developing primary applications in the metallurgical industry based on its unique properties for the treatment of solutions containing values in very dilute concentration. A field with considerable future promise is for electrolytic processes utilizing ion exchange composition in membrane form.

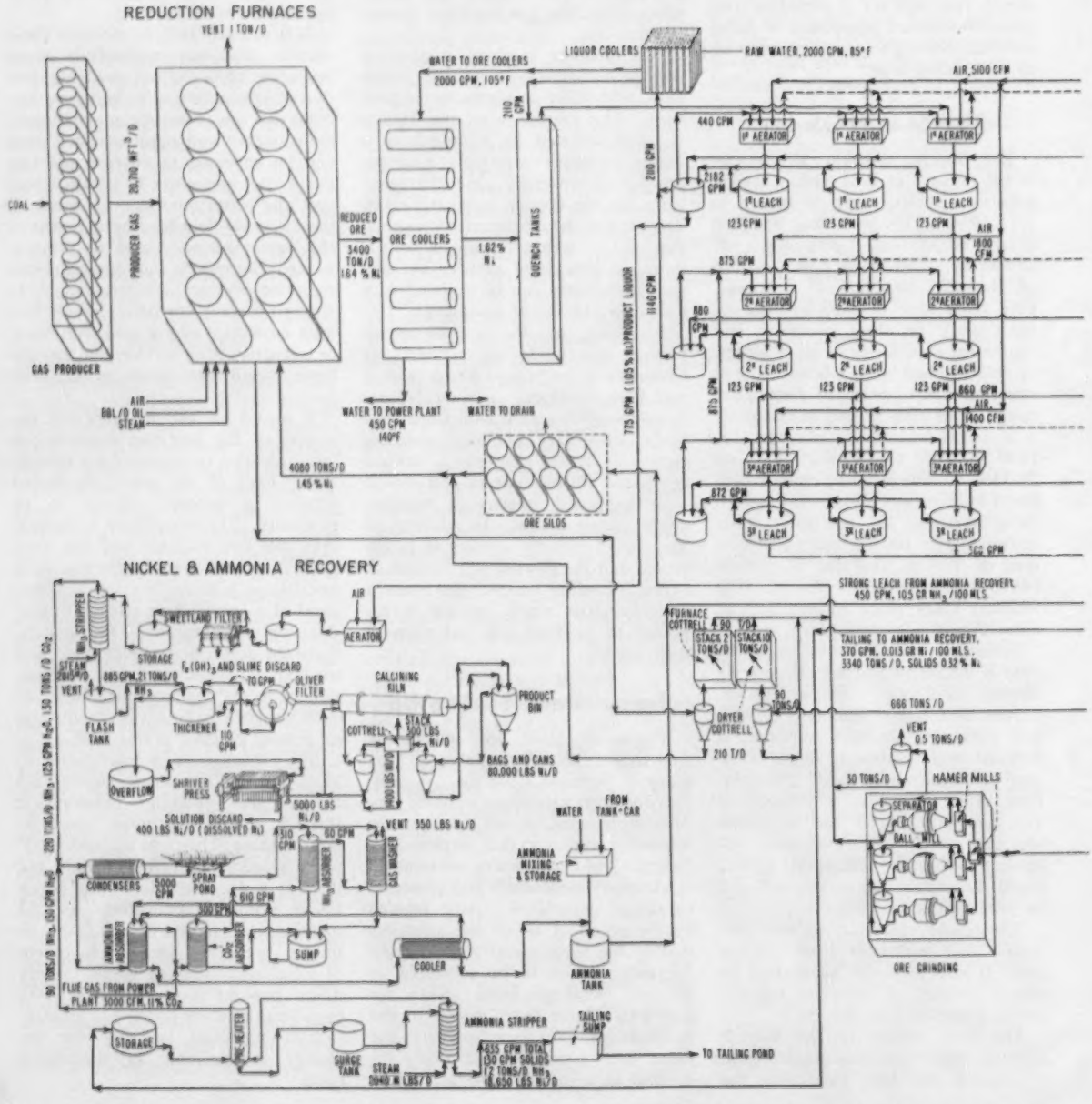
Chemical Techniques Unlock Laterites

A PIONEER IN EXTRACTING NICKEL and cobalt from the laterites of Cuba by chemical-metallurgical processes, is the U. S. Government-owned plant at Nicaro. Originally built and operated for the Government by Freeport Sulphur Co., the plant is now operated by Nickel Processing Corp. (60% owned by National Lead Co.) under a management contract.

Despite the complex mineralogy, Nicaro produces 80,000 lb of nickel a day as a nickel-cobalt oxide (roughly 1% is cobalt) from about 4,000 tons of a limonite-serpentine ore mixture.

Movement of ore and chemical reagents through the plant is clearly demonstrated on the accompanying flowsheet, which includes a quantitative materials balance. Details of the flowsheet which are self-explanatory

NICKEL PROCESSING CORP.



will be omitted in this look at Nicaro's metallurgical practices.

Mine ore, reasonably close to the desired composition of 38% iron, 1.37% nickel and 0.14% cobalt is delivered to an 80,000-ton storage area. Two Gantry cranes handle it there: one bedding the ore to get a thorough mix, the other loading previously bedded ore directly to a plant-bound conveyor.

After the ore has gone through a double roll-tooth crusher to crush lumps, the belt delivers it into the bin at the drying plant, where 2 clamshell buckets feed it through feeders to four rotary-type, Allis-Chalmers dryers, 130 x 11 ft. Here 97% of the moisture is removed at a drying temperature of from 1,800 to 2,000 deg F. Exit gases at 250 deg F carry off about 20% of the charge as dust to a cyclone.

Ore grinding, for more efficient reduction in the furnace, is handled by a hammer mill and separator-ball mill system shown on the flowsheet. About 200 tons an hour goes through the three 9-ft Hardinge ball mills where it is ground to 83% minus 200 mesh.

Reduction furnaces, 12 in number, are 16-hearth Herreshoff furnaces. Fourteen Galusha gas producers are available to supply reducing (producer) gas from anthracite coal. Only 7 of these are now used because it has been found that by using more oil in the furnace, a satisfactory reduction of the ore can be obtained with less coal, a commodity which is more expensive to import. At present, 0.04 ton of coal per ton of ore fed to the furnaces is used, or about 160 tons a day. Oil consumption is 0.29 lb per ton. Addition of more oil than that to save coal would defeat its own purpose by coking up the burners.

In the furnaces, nickel and cobalt must be reduced to metal for later dissolution in the ammonia-ammonia carbonate leach. To do this furnace conditions must be carefully controlled. Temperatures must be held within 5 deg of what practice has shown to be the optima. Critical temperatures are:

Hearth 6	1100 deg F
Hearth 9	1200 deg F
Hearth 11	1280 deg F
Hearth 13	1280 deg F

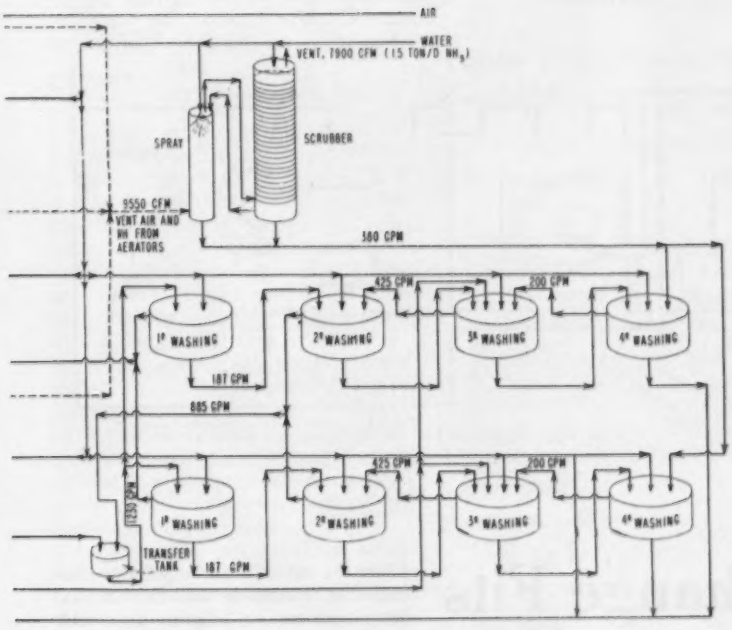
Ratios of H_2/H_2O and CO/CO_2 are carefully held as close to 1:1 as possible since there is a very narrow range in which nickel will be reduced to metal while ferric iron is reduced to the magnetic oxide.

Ore coolers, designed as two concentric shells with ore moving through the annular space and water through the center shell, and the outer shell set in a water bath, are employed to cool 30 to 50 tons of ore each from furnace exit temperature of 900 deg F to 350 deg F. This meant building a liquor cooling tower (see flowsheet) because the ammonia would vaporize at high temperatures and not combine with ore as desired.

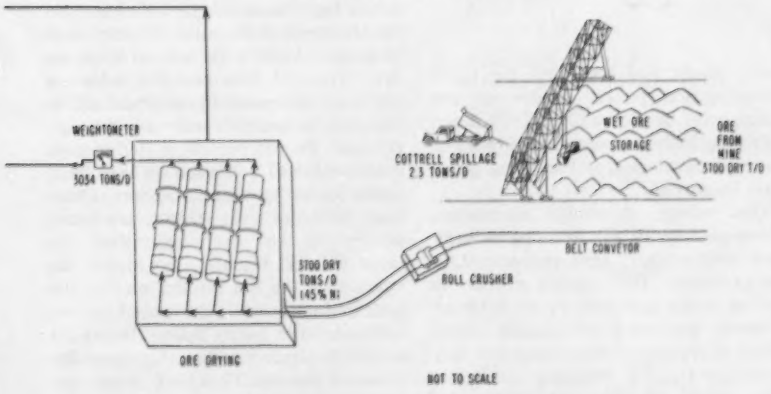
Reduced ore must be cooled in a non-oxidizing atmosphere. If it oxidizes at high temperatures, insoluble nickel compounds will form by recombining of nickel oxide, magnesia and silica. These do not form in later oxidation at lower temperatures. Cooled ore is quenched in ammonia liquor; 11% ammonia, half as hydroxide, half as carbonate. The pulp is pumped from the quench tanks to the aerators with pulp density carefully

(Continued on p 96)

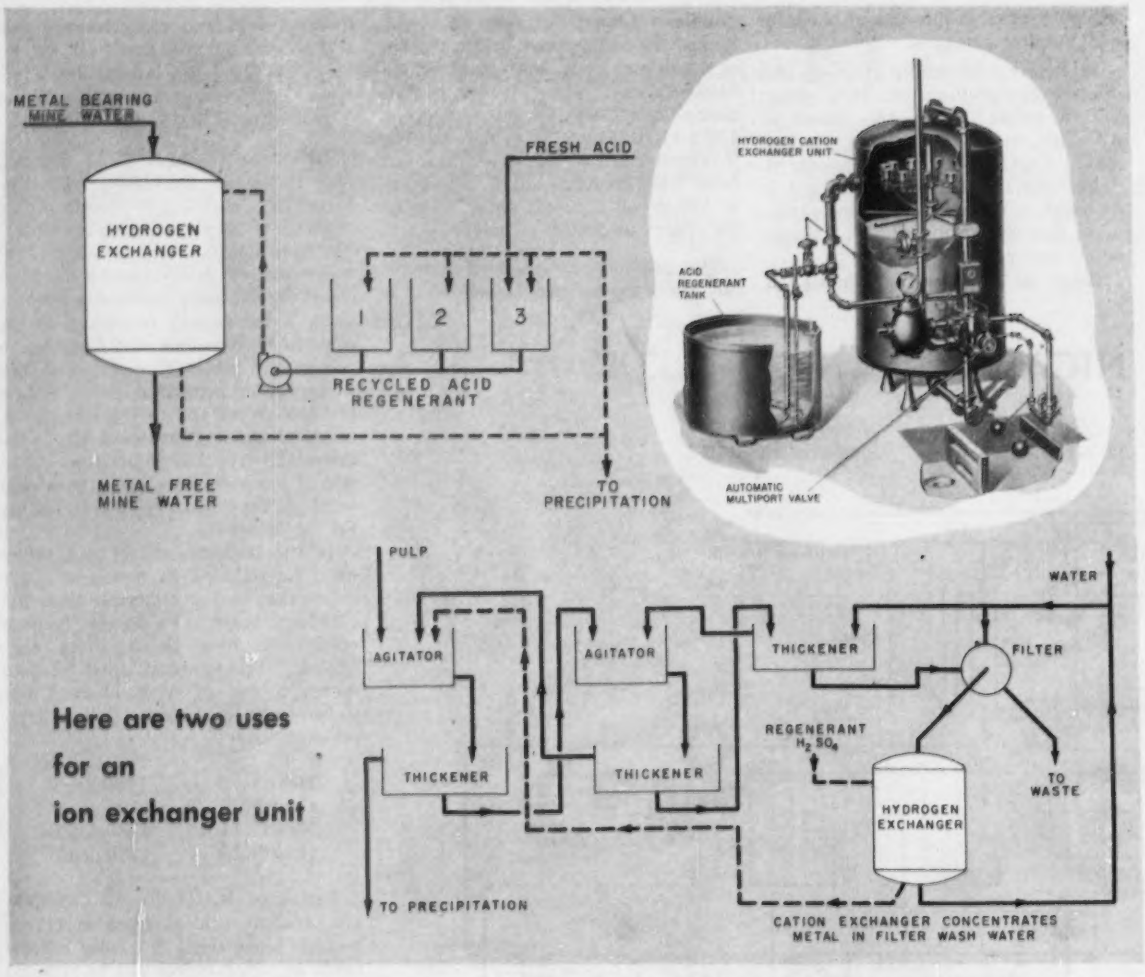
NICARO PLANT



LEACHING & WASHING



NOT TO SCALE



Where Ion Exchange Fits In Hydrometallurgy

A. B. MINDLER
C. F. PAULSON
Permutit Co.

WITH THE EVER INCREASING DEMAND for today's metals and for others whose uses are only now being explored, it is inevitable that wet process metallurgy will be increasingly employed in metals production. Even in the areas of metals which have been in use for hundreds or thousands of years, the increased recoveries which spell the margin between profit and loss, and the more complex and poorer grades of ore which must be worked, can only mean that new hydrometallurgical processes must be developed and existing processes improved.

One newly developed technique, whose potentialities in hydrometallurgy have only recently been recognized, is ion exchange. This age-old process is finding many new uses in all fields of endeavor because it is uniquely suited where conventional techniques fail. Ion exchange usually becomes economically more advantageous, the more dilute the constituents in solution. Ion exchange processes are flexible and equipment can be designed for a minimum of operating attention.

Ion exchange is the interchange of ions in solution with ions on a solid in which there is no substantial change in the structure of the solid. Ion exchange in general follows the laws of mass action. Thus, if two ions for which a resin has substantially identical affinities are contacted with an ion exchanger, the ion present in higher concentration will be found to have been taken up by the ion exchanger. However, different ions seldom are taken up by an ion exchanger with the same affinity. Usually, the higher the valence of the ion (or the smaller the hydrated ionic size—the size of the ion including the surrounding layers of water) the higher is the affinity of the resin for the ion. Thus, in low concentrations of ions in aqueous solution, the

following sequence of affinities apply to cation and anion exchangers:

Cations

$M^{++++} > M^{+++} > M^{++} > M^{+}$

$Th^{++++} > Hf^{++++} > Zr^{++++}$
$Ac^{+++} > La^{+++} > Y^{+++} > Sc^{+++} > Al^{+++}$
$Ba^{++} > Sr^{+++} > Ca^{++} > Mg^{++} > Be^{++}$
$Ag^{+} > Tl^{+} > Cs^{+} > Rb^{+} > NH^{4+} \approx K^{+}$
$> Na > H^{+} > Li^{+}$

Anions

$OH^{-} > SO^{4-} > CrO_3^{-} >$ citrate$^{-} >$ tartrate$^{-} > NO_3^{-} > AsO_2^{-} >$
$PO_4^{-} > MoO_4^{-} >$ acetate$^{-} >$ iodine$^{-} >$ bromide$^{-} >$ chloride$^{-} >$

The rate of ion exchange is almost instantaneous but diffusion rates through the solution, the liquid film surrounding the ion exchange particle, and within the ion exchange particle itself, are controlling factors in conducting ion exchange reactions. Thus, adequate time of contact must be allowed between solution and ion exchanger.

What Ion Exchangers Are

Early ion exchangers were inorganic siliceous materials badly suited for work in hydrometallurgy because they could not withstand the attack of highly alkaline or highly acidic solutions. They could only be regenerated with sodium chloride or other salts. However, in 1935, a sulfonated coal was introduced which could be regenerated with acids and act as a hydrogen exchanger. It now became possible to use ion exchange in acid solutions and to concentrate metals from very dilute solutions on an ion exchanger and regenerate or elute the ion exchanger with an acid to recover the cation as a relatively concentrated metal salt of the acid used for regeneration.

Subsequently, ion exchange resins were developed and marketed which possessed new active groups, both cationic and anionic. During the last 15 years great strides have been made in improved ion exchange resins which offer higher capacity, higher stability—both physical and chemical, and which make possible conducting ion exchange reactions under conditions previously considered impractical.

The following classes of ion exchangers are now commercially available:

Cation exchangers—Organic cation exchangers possess the following active groups:

- Sulfonic
- Carboxylic
- Phosphonic

The cation exchangers most widely used are the sulfonated materials and these are generally of three types:

- Sulfonated crosslinked styrene copolymers
- Sulfonated coals
- Sulfonated phenol formaldehyde resins

Anion exchangers—Anion exchangers are primarily of three types:

- Weakly basic
- Strongly basic
- Those of intermediate basicity

The weakly basic anion exchangers usually possess secondary and tertiary amine groups while the strongly basic anion exchangers possess a large proportion of quaternary amine groups as active groups. Anion exchangers of intermediate basicity have both weakly basic and strongly basic groupings.

Anion exchangers may be used for the exchange of hydroxyl ions or other anions, for anions of dissociated salts or acids. Weakly basic anion exchangers will remove only strong acids. Strongly basic anion exchangers will remove both strong and weak acids including carbonic and silicic acid, when regenerated with caustic soda.

Tables I and II indicate the types and important properties of cation and anion exchangers.

Commercially used ion exchangers are hard, insoluble sand-like granules having a mesh size minus 20 plus 50 (U. S. Standard Sieves). The more recent ion exchangers are bead type or spherical in shape while the earlier ones are granular particles. They range in color from white through yellow and brown to black.

Table I—Commercially Available Ion Exchange

CATION EXCHANGERS

Sulfonated coals
Zeo-Karb P

Sulfonated resins
Phenol Formaldehyde
Zeo-Rex P
Duolite C-3 CP

Cross-linked polystyrene copolymer
Permutit Q P
Amberlite IR-120 RH
Amberlite IR-112 RH
Nalcite HCR (Dowex 50) NA
Duolite C-20 CP

Carboxylic acid resins
Permutit H-70 P
Amberlite IRC-50 RH
Duolite CS-101 CP

Phosphonic acid resins
Permutit XP P
Duolite C-61 CP

ANION EXCHANGERS

Weakly basic
De-Acidite P
Permutit W P
Amberlite IR-4B RH
Amberlite IR-45 RH
Nalcite WBR NA
Duolite A-4 CP
Duolite A-6 CP

Intermediate basicity
Permutit A P
Ionac A-300 P
Duolite A-70 CP

Strongly basic (Quaternary amine)
Type I (Alkyl Amine)
Permutit S-1 P
Amberlite IRA-400 RH
Nalcite SBR NA
Duolite A-42 CP

Type II (Alkanol amine)
Permutit S-2 P
Amberlite IRA-410 RH
Nalcite SAR NA
Duolite A-40 CP

P Permutit Co.
RH Rohm & Haas Co.
NA National Aluminate Corp. (Dow)
CP Chemical Process Co.

Ion Exchange Membranes

Recently, a new form of ion exchangers in sheets or membranes has been developed and intensive experimental work is being carried out in applying these materials and improving their properties. Ion exchange membranes are thin diaphragms of resin possessing active groups similar to conventional granular resins. However, instead of being coarse sand-like granules, they are present as very finely divided particles dispersed throughout a sheet, permitting passage of mainly one specie of ion.

Ion exchange membranes are employed in electrodialysis work. If a cation exchange membrane separates a vessel containing salt water into two chambers, the sodium ions move freely through the membrane in both directions; the chloride ions cannot pass through the cation membrane and remain in the original chamber. If a small electric field is applied, the sodium ions will move through the membrane only in the direction of the negative electrode. At the end of the process all of the sodium is found on one side of the partition, and the equivalent hydrochloric acid on the other side. By suitably constructing a multichambered cell partitioned with cation and anion exchange membranes, a stream of seawater may be continuously divided into a pure water stream and a highly concentrated brine, at the expense of a small amount of electrical energy.

As an example of the economics, desalting of a brackish water of 5,000 ppm electrolytes down to 500 ppm by conventional ion exchange chemicals would cost $1.32 per 1,000 gallons. Treating the same water by a membrane cell electric power would cost only $0.15 per 1,000 gallons. However, there are many other items in the cost that must be included.

Electrodialysis with ion exchange

Table II—Properties for Metallurgical Applications

√—generally recommended	CATION EXCHANGERS				ANION EXCHANGERS			
	Inorganic	Organic			Weakly basic		Strongly basic	
		Sulfonated coal	Sulfonated resins	Carboxylic resin	Granular	Bead	Granular	Bead
Chemical stability								
to acids		√	√	√	√	√	√	√
to alkalies			√	√	√	√	√	√
to oxidation			√	√		√		√
to temperature			√	√		√		√
to organic solvents	√		√			√		√
Physical stability	√	√	√	√	√	√	√	√
For removal of weak acids							√	√
For removal of strong acids					√	√	√	
For high regen. efficiency		√		√	√			
For high capacity			√	√	√		√	√
For low initial exchanger cost	√	√			√		√	
pH range (operating)	6.2–8.7	0–11	0–13	3.5–12	0–12	0–13.9	0–13.9	0–13.9
For high porosity		√			√			
For hydrogen exchange low pH		√	√					
For salt splitting							√	√

membranes offers promise in fields other than water purification: chlorine-caustic manufacture, the concentration of dilute spent pickling acids, waste salts and alkalies, protein demineralization, working up of leach and mother liquors, treatment of conventional ion exchanger regenerant effluents and the separation of certain ions all appear to be practical applications. In the electrochemical industry, energy losses due to mixing of anolyte and catholyte can be minimized by the use of ion exchange membranes as partitions. The increased knowledge being obtained in this field and the improved membranes being developed will soon expand the fields of ion exchange application by facilitating working up regenerant effluents.

How Ion Exchangers Are Used

Practically every commercial scale ion exchange unit employs the conventional percolation column type of operation familiar to almost everyone as the zeolite water softening process. A cutaway view of such a unit is shown on p 56. The solution to be treated, or from which metal ions are to be removed, is passed through a single control multiport valve, or alternatively individual valves, to a distributor at the top of the column. It passes down through the bed and out of the unit under pressure. This is continued until the ion exchanger bed becomes exhausted to its capacity for adsorption of the ion being removed. The bed is then backwashed to cleanse, loosen and regrade it. The ion exchanger is then regenerated or eluted by passage of an appropriate chemical solution through the exhausted bed. Usually in hydrometallurgical processes this is an acid but it may be a salt solution or an alkali. The regenerant or elution solution is introduced through the distributor located just above the bed. The effluent at first is displaced water introduced during backwash. Then the concentration of eluted metal value, present as a salt, increases rapidly until a peak is reached. It then decreases as rinse water is introduced to displace the eluting or regenerating agent.

Several additional steps are sometimes required. To recover and minimize dilution of the solution being treated, a "sweetening-off" step is employed to displace the solution in the ion exchanger with water at the end of the treating run before backwash. Sometimes a conversion step after elution or regeneration is employed to place the proper ion on the resin for exchange.

Under development are procedures for resin-in-pulp application. This would facilitate the application of ion exchange to adsorption similar to the use of granular activated carbon for gold recovery from cyanide solutions. This would eliminate expensive thickening and filtering equipment for clarifying the solution for percolation ion exchange and promises improved yields.

Where Ion Exchangers Are Used

The results which can be accomplished by ion exchange may be classified as follows:

Concentration of valuable ions in solution.

Removal of undesirable ions in solution.

Addition of specific ions in solution.

Separation of mixtures of ions in solution.

Table III is a summary of applications of ion exchange in hydrometallurgy and related fields listing many of the literature references of interest. Many of these references relate to laboratory or analytical work but such reaction can often be developed economically to commercial scale, also.

The cost of ion exchange depends on numerous factors of which the most important are capacity of the ion exchanger for the ion to be exchanged,

cost of regenerant, amortization of equipment, labor, water costs. Only rough estimates of these costs can be presented here since they vary widely for different applications and different parts of the world.

Approximate capacities of the major types of ion exchangers are listed in Table IV. In using these values it must be borne in mind that capacity depends on regeneration dosage, character of ion to be removed, character of other interfering ions in solution, leakage or amount of ion being removed which can be tolerated in the treated effluent. Table IV, giving capacities will serve as a rough guide for establishing the amount of ion exchanger required.

Having established the quantity of resin required to conduct a certain operation on a daily basis, the number of runs per day is estimated from a time study of the steps involved in the operation. From this, the volume of resin required in the installation can be established. Fig. 2 gives an approximate installed cost of units of different types and sizes. Approximate operating costs are given in Table V.

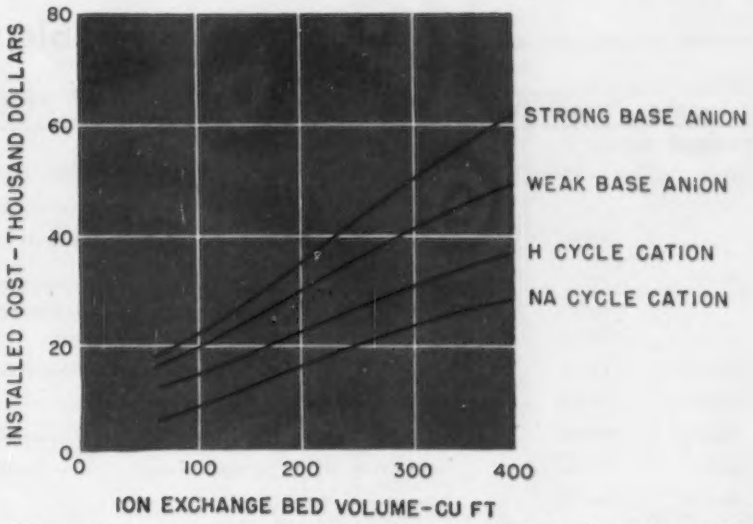


FIG. 2. Cost of an ion exchange installation depends primarily upon capacity, cost of regenerant, amortization, labor and water costs.

Table IV—Ion Exchanger Capacities

	meq/l	kgr/cu ft as $CaCO_3$	lb equiv 100 cu ft
Cation—hydrogen cycle			
Sulfonated coal	360	8	2.5
Sulfonated polystyrene	450–900	10–20	3–6
Anion—acid removal			
Weak base	700	16	5
Strong base	540	12	4
Anion Exchange			
Weak base	540	12	4
Strong base	450	10	3

Table V—Operating Costs

Operating costs $ per lb-equivalent of ion removed

Na cycle cation exchange	$3.81
H cycle cation exchange	7.31
Weak base anion exchange	5.80
Strong base anion exchange	15.25

Limitations of Ion Exchange

Since ion exchange reactions are controlled largely by the Law of Mass Action and exchange proceeds rigidly in chemical equivalents, certain limitations in the application of ion exchange must be borne in mind. An ion exchanger is effective for adsorbing a specific ion only if the concentration of interfering ions in the solution does not exceed a tolerable level. Thus, while it is possible to adsorb iron cations from a chromic or phosphoric acid solution of 35%, the removal of iron from a 5% sulphuric acid is not feasible. This is due to the difference in concentration and activity of the interfering hydrogen ion in the two solutions because of widely different degrees of dissociation.

Separation of mixtures of ions depends on the relative concentrations and characteristics of the ions comprising the mixture. Difficult separations of rare earths have been developed, but these depend on special elution procedures such as complexing, and not on differences in adsorption. Since each ion exchanger has a limited capacity for adsorption of ions, the concentration of the regenerant or elution effluent is limited. Even by employing recycling procedures for regenerant effluents, the void space between ion exchange particles, the imbibed solution inside the particles, and resistance to diffusion of ions by the liquid film and the resin structure all contribute to a limited concentration of salts in the recovered elution solutions. Thus, ion exchange is seldom employed to concentrate ions from solutions containing over a few tenths percent concentration since recovered solutions rarely exceed 10% concentrations.

There are also certain limitations in the chemical and physical characteristics of ion exchange materials. Recently developed ion exchange resins possess remarkable stability toward reducing conditions, highly oxidizing conditions, extreme alkaline or acidic pH, and high temperatures over many cycles. The styrene copolymer cation exchanger, Permutit Q, for example, is not affected noticeably in many cycles when treating solutions containing 1,000 ppm chlorine, or at pH 11 to 12 or in softening hot process water at 250 deg F. Attrition rates under normal conditions of operation are only a few percent per year. However, certain solutions contain substances which may be adsorbed by the ion exchanger and not completely regenerated off by the conventional regeneration or elution procedures. Such difficulties result in gradually decreased capacities and reduced reaction rates which can usually be restored by appropriate chemical treatment applied at intervals. Some metals are more difficult to remove from cation exchangers than others by conventional regeneration techniques. Strong acid treatments or other special chemical treatments may be required intermittently where such metals may be present. Certain complex metal ions may also act as poisons and require removal by chemical treatment at intervals.

Physical poisoning of the ion exchanger may also occur. In conventional ion exchange equipment of the percolation type the solutions to be

Table III—Tabulation of Ion

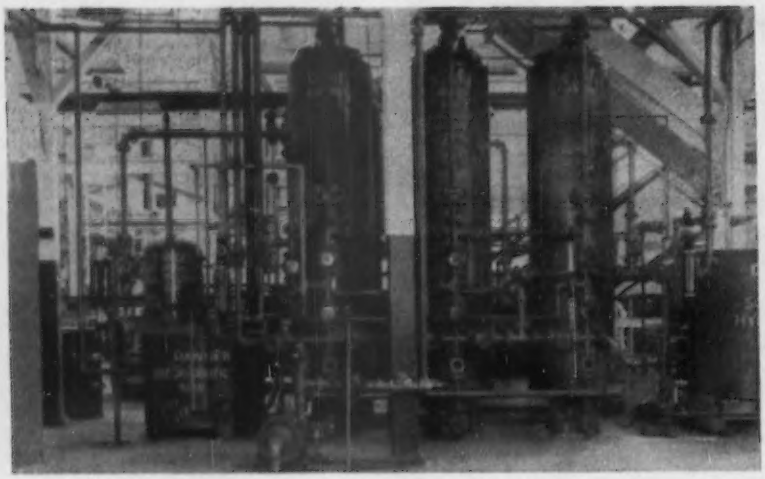
LEGEND: CS Sulfonated cation resin CC Carboxylic cation resin

METAL	IONIC CHARACTER	HYDRO-METALLURGICAL PROBLEM	CONDITIONS	SUMMARY OF WORK	ION EXCHANGER	REFERENCES
PRECIOUS METALS						
Gold	$Au(CN)_2^-$	Concentration from slimy ores	Cyanided pulp	Lab concentration	AW, AS	N2, H6, P5, M6, B11
		Separation of complex leach solution	Cyanide solution Ag, Fe, Cu, Co, Ni, Zn	Lab separation by elution	AS	B10
	$Au(Cl)_4^-$	Concentration of anionic complexes	Pure solutions	Lab concentration	AW, Salt form	S14
Silver	Ag^+	Concentration	Sea water	Patent specification	CS, Manganese form	B8
	$Ag(S_2O_4)^-$	Recovery	Photographic rinses	Lab and pilot plant	AW, Salt form	A2, D5, M10
	$Ag(CN)^-$	Concentration	Cyanided pulp plating wastes	Lab	AW, Salt form	B10
Platinum	$Pt(Cl)_6^=$	Separation	Nitrate-chloride complex	Selective elution	CS, Hydrogen form	S13
Palladium	$Pd(Cl)_6^=$	Concentration	Chloro complex	Lab concentration	AW, salt form	S14
Rhodium	$Rh(Cl)_6^=$	Purification	Anion complex	Lab impurity removal	CS	C1
Iridium	$Ir(Cl)_6^=$	Concentration	Synthetic solution	Quantitative lab absorption	AS	M1
Rhenium	$Re(Clt)^-$	Separation from Mo				F3
BASE METALS						
Copper	Cu^+, Cu^{++}	Concentration	Synthetic sulfate solution	Acetate regeneration	Inorganic, sodium form	A5
	Cu^+, Cu^{++}	Concentration	Synthetic sulfate solution	Equilibrium studies	CS	B2, S7
	Cu^+, Cu^{++}	Concentration	Synthetic sulfate solution	HCl elution, HCl recovery	CS	T1
	Cu^{++}	Separation of amines	Cu-Ni, Cd-Zn, Ag-Cu	Lab separation	CS	K9
	$Cu(NH_3)_4^{++}$	Concentration	Cupra-ammonium rayon wastes	Lab study Plant scale	CS CS	N3, P1 G6, G1, K16, T5, B4
	Cu^{++}	Separation	Cu, Zn	Lab separation at low flow rate	CS, CC	B7
Iron	$FeHPO_4^+$	Separation	H_3PO_4 solution	Lab absorption	CS, H form	S1
	$Fe(CN)_6^=$	Concentration	Acid complex	Lab concentration	AW, Salt form	S14
	Fe^{+++}	Separation from aluminum	Sulfate solutions	Analyses	AS, sulfate form	K8, K15
Zinc	$Zn(CN)_4^=$	Recovery	Alkaline plating waste	Lab survey	AS	W1
	Zn^{++}	Concentration	Acid solutions	Lab survey of effect of acid on capacity	CS	M8, G5
	Zn^{++}	Concentration	Acid rayon wastes	Plant design data	CS	P5
	Zn^{++}	Separation from Cu, Co, Fe, Mn	Strong HCl	Lab separation Zn not not held	AS	K10
Lead	Pb^{++}	Concentration	HNO_3	Lab adsorption for analysis	CS	D1, G3, K7
Tin	$SnO_3^=$	Concentration and recovery	Alkaline plating rinse water	Conversion of salt to free insoluble acid	CS, H form	M8, K5
Aluminum	Al^{+++}	Separation from Be		Al held, Be passes through	CS, Ca form	K1
ALKALI METALS						
Lithium	Li^+	Separation from potassium	1.0 N HCl	Continuous ion exchange separation	CS	S3, H3
Sodium	$Na(SO_4)^-$	Formation of NaOH	Sea water	Electrolysis of Na_2SO_4 with SO_4 recovery	AW	U1
	Na^+(or other alkali)	Formation of NaOH	NaCl solution 10%	Lime regeneration	AS	A1
Potassium	K^+	Separation from Ca, Na	Sea water	Enrichment of process liquor in K^+	Nitrated polyamine	S9
ALKALI EARTHS						
Magnesium	Mg^{++}	Concentration	Sea water	Patent specification	CS, sodium form	O1
	Mg^{++}	Concentration	Sea water	Patent specification	CC	H5, G4
	Mg^{++}	Concentration	Sea water	Production of $Mg(OH)_2$ by NH_3 exchange	CS, NH_3 form	B1
	Mg^{++}	Concentration	Sea water	Continuous process 20% NaCl regenerant	CS	M4
Radium	Ra^{++}	Separation from Ba^{++}	Salt solution	Adsorption of mixture, separation by elution with carboxylic acid	CS	T4
Barium	Ba^{++}	Separation from lead	Salt solution (HNO_3)	Elution with $NH_4(CH_3COO)$	AW	M7
Strontium	Sr^{++}	Separation from V^{+4}, Fe^{+3}, Cu^{+2}, Ni^{+2}, Co^{+2}	Citrate complex	Elution separation	AS, Cl form	T3, S8, S5
Calcium	Ca^{++}	Separation from rare earths	Citrate elution	Lab separation	CS	B6
	Ca^{++}	Separation from alkali metals	Salt solutions	Lab separation	CS	N1, W2

Exchange Applications

AW Weak base anion resin AS Strong base anion resin

METAL	IONIC CHARACTER	HYDRO-METALLURGICAL PROBLEM	CONDITIONS	SUMMARY OF WORK	ION EXCHANGER	REFERENCES
MINOR METALS						
Arsenic	$AsO_3^{=}$, $AsO_4^{=}$	Separation from iron	Salt solution	Fe^{++} held, arsenic passes through	CS, Na form	Y1
	AsO_2^{-}	Separation from antimony and tin	Adsorption from acid	Arsenic as anion is not held	CS	L2
Beryllium	Be^{++}, Be_2O_3	Polymerization	Perchlorate solution	Lab	CS, NH^+ form	F2
	Be^{++}	Separation from Al	Al, Be salts		CS	K2
Antimony	Sb^{++}	Separation from tin	Tartaric acid	Lab, Sn^{++} held	CS	K5
	Sb^{++}	Separation from As, Sn	Salt solutions	Lab, separation by HCl elution	CS	L2
Bismuth	Bi^{++}	Concentration	Acid solutions	Bi absorbed	CS	P6
	Bi^{++}	Separation from lead and copper	Salt solutions	Adsorption of all, then removal of Bi by acid K1 solution	CS, K^+ form	L2
Cadmium	Cd^{++}	Separation from uranium	Oxalate solutions	Elution separation	CS	D3
Tungsten	$WO_4^{=}$	Formation of insoluble free acid	Tungstate salt solutions	Conversion of salt to free acid	CS, hydrogen form	B5, R2
Molybdenum	$Mo(O_4)^{=}$	Concentration	Salt solutions	Lab, $(NH_4)_2(MoO_4)$	AW, Cl form	S14
	$Mo(cit)^{=}$	Separation from rhenium	Mo complex	Lab, citrate complex Mo not absorbed	CS	F3, K6
Vanadium	VO_3^{-}	Separation from PO_4	H_3PO_4 solution	Recovery of V	CS	S2
Cobalt	Co^{++}	Separation	Reineckes salts	Lab study on complexes	CS	M3, L1, A6
Nickel	Ni^{++}	Separation from Co	Strong HCl	Co held strongly	AS, Cl form	M9
	Ni^{++}	Recovery from waste	Acid plating rinse	Pilot plant tests	CS	F1
	Ni^{++}	Separation from iron	$SO_4^{=}$ solution	Iron absorbed, Ni passed	AW	K18
Chromium	$CrO_4^{=}$, $Cr_2O_7^{=}$	Concentration	Plating rinse	Plant operation	AS	P3, P4, F1
	$CrO_4^{=}$, $Cr_2O_7^{=}$	Removal of impurities	Strong CrO_3 solution	Plant operation	AS	P3, P4, P2
	$Cr(SCN)^{=}$	Concentration	SCN Complexes	Lab	AS	K4
Tantalum	Ta	Separation from niobium	Strong HCl	Separation by elution	AS	G2, K13
Zirconium	Zr	Separation		Lab, removal of Fe, Ti, Be, La from colloid	CS	A7, A8, B9
	Zr, Hf	Separation from hafnium	Mixed HCl, HF	Lab	CS	B9, F5, K11
	Zr	Separation from aluminum		Lab	CS	F6
	Zr, Hf	Purification	Dilute HNO_3	Lab	CS	A7, B3
Colombium (niobium)	Nb	Separation	Strong HCl	Lab, Nb held	AS, salt form	H4, K12
	Nb	Separation	Oxalic acid solution	Lab purification	AS	G2
Titanium	Ti	Separation from Zr, Th	Citric acid solution	Selective elution	CS	B9
Thorium	Th	Separation from rare earths	Elution with citrate complexes	Lab	CS	R1
Selenium	Se	Separation from tellurium		Lab	CS	A4
Indium	In	Separation	Complex with Cl, F, Br	Lab separation by fluoride complexes	CS	H2, S7
Francium	Fa	Separation from rare earths	Silicotungstic acid solution	Lab separation	CS	H7
RARE EARTHS						
Actinides	Pu, Pa, U, Np, Am, Cm, Th	Separation	Citrate complexes	Lab separation by selective elution	CS	D2, H4, A7, A6, F4
Uranium	UO_2^{++}	Separation from cadmium	Oxalate solutions	Lab separation by elution	CS	D3
	UO_2^{++}	Separation from rare earths	Oxalate solutions	Lab separation by elution	CS	D4
	UO_2^{++}	Separation from rare earths	Batch operation	U recovered by incineration	CS	A3
Neptunium	Np	Separation from uranium	Nitric acid solution	Lab separation	CS	J1
Technetium	Tc	Separation from Mo, Co, Ag	Ammonium thiocyanate eluent	Lab separation	AS	H1
Curium	Cm^{+++}	Purification	Citric acid eluent	First isolation	CS	W3
Proactinium	Pa	Separation from niobium, tantalum	HCl-HF mixtures	Lab separation	AS	K14
Lanthanides	Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	Separation	Salt solutions complex elution	Lab elution	CS	A7, A8, F4, T3, S10, S12, K3, B6, T2, S6
Cerium	Ce^{+++}	Separation from rare earths	Citric acid elution	Lab separation	CS	F7, F8
Praseodymium	Pr^{+++}	Separation	Citrate elution	Lab separation	CS	S11
Samarium	Sm^{+++}					
Neddymium	Nd^{+++}					
Europium	Eu^{+++}	Separation from samarium and terbium	Ethylene diamine tetra acetate eluent	Complex elution	CS	M2



Unit at Wichita, Kan., plant purifies chromic acid, recovers chromate.

treated must be clear and free of suspended matter. Generally turbidities above 10 or 20 ppm lead to difficulties unless the periods are short between backwashes. Precipitation in the bed during the adsorption period or during the regeneration or elution portion of the cycle also may lead to rapid decreases in capacity and efficiency.

The unique reactions which can be accomplished by ion exchangers operating under the proper conditions and in well designed equipment can only mean the increased adoption of this useful new tool in wet process metallurgy and allied fields. Already ion exchange is being employed commercially in the production of metals ranging in value from copper to platinum and in the purification of solutions no more valuable than dilute sulphuric acid. The unique properties of ion exchangers permit their use in filling the gaps of other unit operations in improving efficiency and simplifying plant operations of the modern hydrometallurgical industry.

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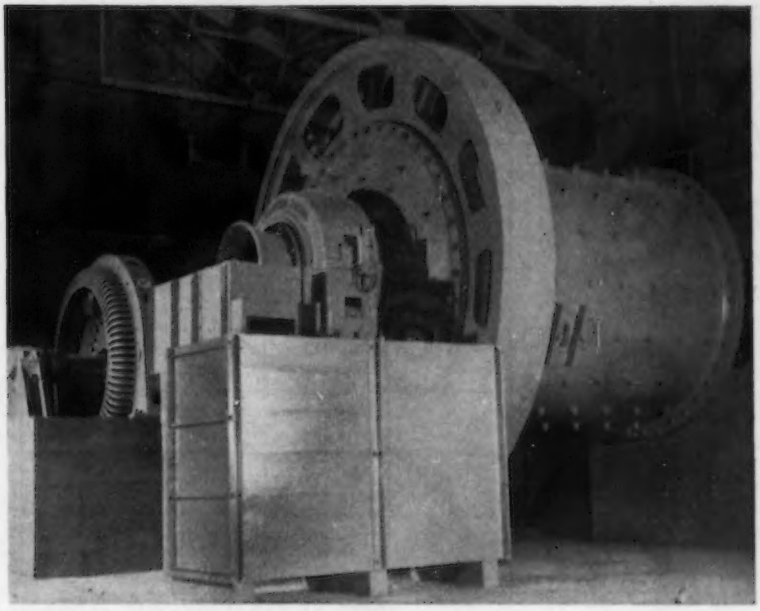

How much power is needed for a proposed rod mill? Methods of estimating are apt to give widely varying results. Now there is a surer method.

How To Predict Rod Mill Power Requirements

NATHANIEL ARBITER
Columbia University

There is now available a method for accurately predicting tumbling mill performance entirely from operating data with no assumptions whatsoever as to grinding theories. The method should go a long way in reducing ulcer frequency in mill men faced with design or expansion problems.—Editor.

THE TUMBLING MILL, loaded with steel balls or rods, pebble or mine rock, is the only practical machine used today for grinding ore. Its principal operating characteristics are its power draft, its tonnage capacity to grind a particular ore from a given feed size to the desired product size, and its consumption of grinding media and liners.

Present methods for estimating these characteristics are generally unsatisfactory. It is common knowledge that for a given proposed installation, estimates by different mill manufacturers can differ significantly. In the face of this situation the need for more reliable prediction charts or equations is apparent. The purpose of this article is to introduce a useful method for obtaining such charts and equations entirely from operating data with no assumptions whatsoever as to grinding theories. The correlation to be presented here is for the power requirements of rod mills as determined by diameter, length, charge density, speed and rod load. Similar correlations are being developed for ball mill power draft and for grinding capacity and reduction ratio in terms of mill and ore variables.

Dimensional Analysis

The method used to obtain these correlations is based on dimensional analysis, a technique of wide application in other branches of engineering and science.[1] In brief, the procedure consists in identifying the variables controlling a phenomenon, in combining these variables into dimensionless groups according to definite rules, and in determining the relationship among the small number of groups rather than among the larger number of single variables. This not only simplifies experimentation and leads to concise representation of data by charts or equations, but often gives theoretical insight into complex physical or chemical problems.

The detailed application of dimensional analysis to the correlation of the power draft of rod mills has been described elsewhere.[2] It was there shown that appropriate dimensionless groups consist of the "fraction critical speed"

$$F_c = 0.01305N\sqrt{D}$$

the load fraction (fraction of mill volume occupied by rods = L_f); and a power factor

$$\frac{HP}{\rho D^{3.5} L g^{1.5}} = P_f'$$

For practical purposes the gravitational constant g can be eliminated from the power factor leaving the term

$$\frac{HP}{\rho D^{3.5} L} = P_f$$

Model Mills

Fig. 1 presents data for the power factor against the combined load-speed factor $F_c L_f^{0.27}$ for three small rod mills. The Columbia model[2] was 1 ft by 1⅓ ft, the Coghill[3] model 1 ft 7 in. by 3 ft, and the Mitchell[4] mill 2½ ft by 4 ft.

All plotted data show a linear relationship between the power factor and the load speed factor, indicating an equation of the form

$$\frac{HP}{\rho D^{3.5} L} = A + BF_c L_f^{0.3}$$

The intercept A is usually sufficiently small to be ignored. The lines for the three mills differ in slope, with the Columbia and Coghill models sufficiently close to be considered identical, but with the Mitchell mill characterized by a definitely lower slope.

The value of the slope of these equations is determined by the variables which have not been correlated in this study: e.g. rod diameter, pulp particle size, type of lifter, type of discharge, etc. However, based on studies of the dry rod charge without ore, it is suggested that slip is responsible for lowering the power factor from its value with the dry charge. Thus with the Columbia model without lifters, the presence of pulp causes a substantial drop in power factor as compared to the dry rod charge, and marked slip. This power drop is almost entirely eliminated by lifters. It is therefore suggested that the lower

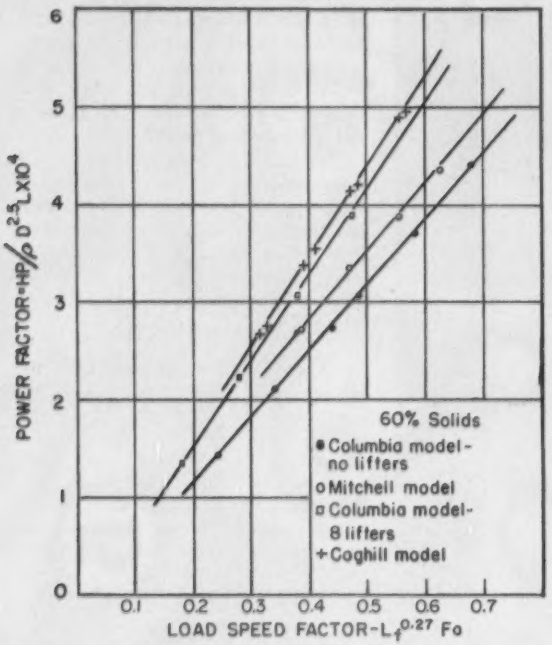

Fig. 1. Relationship between power factor and load speed factor is linear. Variables determine slope.

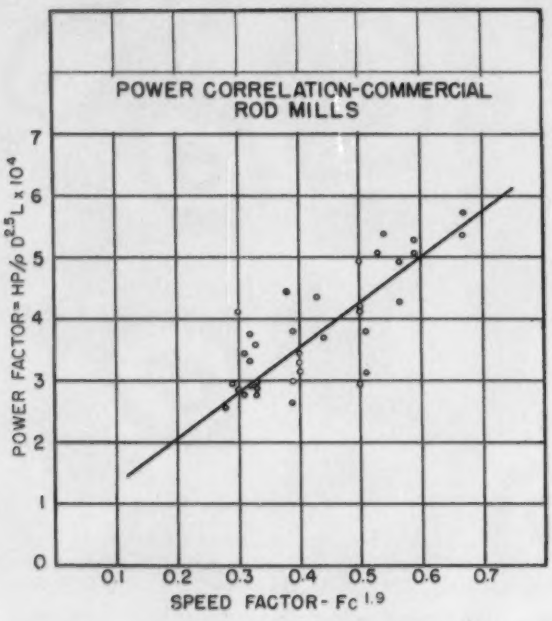

Fig. 2. Commercial rod mills show power factor proportional to fraction critical speed to the 1.9 power.

power factor with the Mitchell mill may be due to a greater amount of slip than occurred in the Columbia and Coghill mills.

The effect of slip on power factor is due primarily to the discrepancy between the shell radial velocity and the radial velocity of upcoming rod layers. This has the consequence of producing a charge configuration and action corresponding to a lower shell velocity. Thus a mill with slip requires a higher shell velocity than a mill without slip to obtain the same tumbling action.

Commercial Mills

All available commercial rod mill data have been analyzed in terms of the same dimensionless groups used with model rod mills. The data are contained in Table 1 and the correlation line in Fig. 2. The data were grouped according to load factor and the dependence of power factor on fraction critical speed determined. It was established that the power factor was proportional to fraction critical speed to the 1.9 power.

No effects of load variations in the operating data could be detected. This does not mean that variation in rod load does not affect power, but rather that its effect is masked by the effects of uncontrolled variables discussed below. The 0.27 exponent for load factor developed for the small mills indicates that a variation in load from 30 to 45% which covers the operating range, could increase power draft by only 11%. A load variation of 5% around the average 39% load level would affect power by only 3% either way. More controlled operating data are necessary to establish the exponent rigorously for large mills. Until such data are available it is suggested that the relationship

$$\text{(Equation 1)}\quad \frac{HP_1}{HP_2} = \left(\frac{L_{f1}}{L_{f2}}\right)^{0.27}$$

be used for estimating load variation with a particular mill.

Symbols

- HP Horsepower: Net for model mills, gross for commercial mills
- ρ Charge density: taken as 411 lb per cu ft for rod mills
- D Mill diameter
- L Mill length
- F_c Fraction critical speed
- N Mill speed rotations per minute
- L_f Load fraction: fraction of mill volume filled by load
- $P_{f'}$ Dimensionless power factor $= \dfrac{HP}{\rho D^{2.5} L g^{1.5}}$
- P_f Practical power factor $= \dfrac{HP}{\rho D^{2.5} L}$

Causes of Deviation

The power factor versus fractional speed relationship is statistically significant as indicated by a correlation coefficient of over 0.9. The deviation of individual points from the correlation line can be due to one or more of the following factors:

1. Variation in motor efficiencies and transmission losses. Taggart[5] states that friction losses can vary from 11 to 40%.

2. Use of nominal mill diameters without regard to linear wear. Normal wear of liners can cause as much as 20% increase in power.

3. Liner shapes in the table include smooth, wave, and shiplap. The effect of lifters in the Columbia model mill was to increase power by from 20 to 30% depending on speed.

4. Pulp dilution varies from 60 to 85% solids. This can have a minor effect on power.[3]

5. Type of discharge can effect power.[3]

6. Rod size and feed size in their ratio to mill diameter can affect power. Coghill[3] showed that increase in rod

Table 1: Power Correlation of Commercial Rod Mills

	Name of Plant	Diameter D, ft *	Length L, ft	Load Fraction L_f **	Fraction Critical Speed F_c	$F_c^{1.9}$	Gross Horse-power Hp	Power *** Factor $P_f \times 10^4$	Calculated Power ****
1.	Morenci	3	7	0.33	0.69	0.50	18.6	4.12	19.4
2.	Morenci	3	7	.37	.69	.50	22.5	4.99	19.4
3.	Colquiri	3	8	.32	.77	.54	27.6	5.39	23.6
4.	Old Dominion	4	8	.41	.65	.44	39	3.70	41
5.	Colquiri	4	8	.38	.64	.43	46	4.37	40
6.	Colquiri	4	10	.35	.69	.50	55	4.18	58
7.	Desloge	4	10	.46	.70	.51	50	3.80	45
8.	Flat River	5	9	.41	.60	.38	95	4.45	73
9.	Midvale	5	10	.26	.52	.29	68	2.96	63
10.	Federal	6	12	.48	.53	.30	180	4.14	123
11.	Mine La Motte	6	12	.38	.53	.30	180	4.14	123
12.	Copper Queen	6	12	.29	.56	.33	125	2.87	132
13.	Old Dominion	6	12	.32	.56	.33	130	2.99	132
14.	Cananea	6	12	.33	.51	.28	110	2.53	116
15.	Moctezuma	6	12	.27	.56	.33	120	2.76	132
16.	Potosi	6	12	.33	.54	.31	120	2.76	126
17.	Flat River	6.5	12	.35	.56	.33	190	3.57	162
18.	Balmat	6.5	12	.45	.55	.32	177	3.33	157
19.	Chino	7	10	.28	.69	.50	155	2.91	229
20.	Ray	9	12	.34	.55	.32	352	2.94	352
21.	International Nickel	6.5	12	.32	.55	.32	201	3.78	157
22.	International Nickel	6.5	12	.30	.61	.39	203	3.82	185
23.	International Nickel	6.5	12	.35	.81	.67	304	5.68	298
24.	Tennessee (Isabella)	6	9	.45	.76	.59	165	5.06	167
25.	Tennessee (London	6	12	.45	.70	.51	136	3.12	191
26.	Tennessee (London)	6	12	.45	.61	.39	131	3.01	151
27.	Tennessee (London)	6	12	.45	.75	.53	220	5.06	197
28.	Tennessee (London)	6	12	.45	.75	.53	220	5.06	197
29.	Tennessee (Isabella)	6	9	.45	.76	.59	172	5.28	162
30.	C-1 (See ref.)	9	12	.38	.53	.30	345	2.87	339
31.	Waite-Amulet	9	11.5	.35	.61	.39	300	2.61	400
32.	St. Joseph	6.5	12	.60	.54	.31	182	3.43	153
33.	Sullivan	10.75	12	.38	.81	.67	1000	5.35	1040
34.	Sullivan	10.75	12	.38	.74	.57	800	4.28	900
35.	Sullivan	10.75	12	.48	.74	.57	920	4.92	901
36.	Snow Lake	8	12	.40	.62	.40	296	3.31	318
37.	Snow Lake	8	12	.40	.62	.40	283	3.16	319
38.	Snow Lake	8	12	.45	.62	.40	308	3.45	318

* Nominal, except 34-36 (I.D.) ** Density of rod load used in calculating L_f when L_f is not available, 390 lbs per cu ft.

*** $P_f = \frac{HP}{pD^{2.5}L}$, = 411 lbs per cu ft. Hp = gross horsepower. **** $\frac{HP}{D^{2.5}L} = 0.305\ F_c^{1.9} + 0.024$

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33-35 Banks, H. R., The Rod Mill in the Sullivan Flow sheet. Canadian Mining and Metallurgical Bulletin, V. 45 (1952) 397
36-38 MacDermid, B. G., Rod Milling at Snow Lake, Canadian Mining and Metallurgical Bulletin V. 46 (1953) 535

diameter from 0.9 to 1¼ and 1½ in. significantly increased power in his 19 by 36-in. mill. He also showed that power dropped 8% in grinding a 10 mesh feed to a 28 mesh product in a batch operation.

Use of Correlation

From the correlation chart or the equations derived from it, power as determined by mill size and speed can be estimated. The equation with charge density at 411 pounds per cu ft included in the constant is

(Equation 2) $\frac{HP}{D^{2.5}L} = 0.305\ F_c^{1.9} + 0.024$

Departure from 39% rod load level can be corrected for by using Equation 1.

The practical value of the correlation is illustrated by the comparison of observed and calculated power in Table 1; the average difference is under 10% if five mills showing gross discrepancies are not included in the average, which may easily be justified.

The fact that such deviations occur does not mean either that the correlation is invalid or that the individual mill data are in error. Factors discussed above in addition to those correlated, can significantly affect power. As more extensive data become available it will be possible to take account of the other variables in the correlation.

Acknowledgments

The experimental work cited was performed by Dr. P. K. Guerrero as part of his doctoral thesis at the School of Mines, Columbia University. Mr. I. H. Redeker, Campbell Fellow at the School of Mines, carried out the study on the effect of lifters in the model rod mill.

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3. Coghill, W. H. and DeVaney, F. D. "Ball Mill Grinding" T. P. 581. U. S. Bureau of Mines 1937.
4. Mitchell, Will Jr. et al. *Mining Engineering*. Vol. 1, No. 10, October 1954, p. 1001.
5. Taggart, A. F. et al. "Handbook of Ore Dressing." Wiley, N. Y. 1945.

Flotation Reagents*

(Letters in parentheses refer to these manufacturers.)

A Rohm & Haas Co.
B Union Carbide & Carbon Corp.
C Ciba Co.
D Oronite Chemical Co.
E Allied Chemical & Dye Corp.
F Marathon Corp.
G W. Va. Pulp & Paper Co.
H American Gum Products Co.
J Baker Castor Oil Co.
K Emery Industries Inc.
L Industrial Oil Products Corp.
M E. I. du Pont de Nemours & Co.
N Commercial Solvent Corp.
P Minerec Corp.
Q Dewey & Almy Chemical Co.
R Sharples Chemicals, Inc.
S American Cyanamid Co.
T Newport Industries, Inc.
U Pacific Lumber Co.
V Philadelphia Quartz Co.
W General Mills, Inc.
X Armour & Co.
Y Dow Chemical Co.
Z Hercules Powder Co.

Fr	P	C	Fc	Di	M	Fl	De	W	A	E	Reagent and Mfr.	What It Is	Remarks
Fr	P										Acid Sludge	Byproduct	Bulk sulphides
Fr			Fc					W			Aciterge OL	Catonic surface active reagent	Nonmetallics in acid circuit-slime flocculator
						Fl					Actinol C	Crude tall oil	Nonmetallics
						Fl					Actinol D	Refined tall oil	Nonmetallics
Fr	P										Aerofloat 15 (S)	15% Phosphorus pentasulphide in cresylic acid	Gold, sulphides of Ag, Cu, Pb, Zn
Fr	P										Aerofloat 25 (S)	25% phos. penta.	Sulphides in acid or neutral circuit, non selective
Fr	P										Aerofloat 31 (S)	31% phos. penta.	Galena, oxidized gold ores, silver sulphides
	P										Aerofloat 203 (S)		Au, Ag, Cu, Zn sulphides
						Fl					Aerofloat 208 (S)		Gold and silver
	P										Aerofloat 211 (S)		Selective Zn reagent
	P										Aerofloat 213 (S)		Au, Ag, Cu ores—Tendency to froth
	P										Aerofloat 226 (S)		Similar to 213
	P										Aerofloat 238 (S)		Au, Ag, Cu, Zn sulphides
Fr	P										Aerofloat 241 (S)	Neutralized Aerofloat 25	Silver bearing lead, copper, zinc sulphides
Fr	P										Aerofloat 242 (S)	Neutralized Aerofloat 31	Cu, Pb, Ag sulphides
	P										Aerofloat 243 (S)	Water soluble, dry aerofloat	Au, Ag, Cu, Zn sulphides
Fr	P										Aerofloat 249 (S)	Water soluble aerofloat	Non-selective sphalerite, copper sulphides, gold ore
						Fl					Aerofloc (S)	Synthetic organic	Improve settling, aid filtering
				Di				W			Aerosol OT (S)	Sodium salt of dioctyl-sulfosuccinic acid	Oxides, nonmetallics
						Fl					Alamac	Acetate Tallow amine	Feldspar, potash, phosphate
						Fl					Alamac 26-D	Acetate distilled tallow amine	Same as above
						Fl					Alamac 26	Tallow amine	Nonmetallics
	P	C									Aliphat 44A	Double distilled tall oil fatty acids	Nonmetallics
	P	C									Aliphat 44B	Distilled tall oil fatty acids	Nonmetallics
	P	C									Aliphat 44E	Fractionally distilled tall oil fatty acids	Fluorspar
										E	Alkaterges A, E, and T (N)	Cationic oil soluble surface active agents	Nonmetallics
Fr								W		E	Alkaterge C (N)	Non-volatile cationic surface active amine	Nonmetallics
			Fc								Alum	$Al_2(SO_4)_3 \cdot 18H_2O$	Slimes
				Di							Amijel	Form of corn starch	Gangue slimes
Fr	P										Amine 220	Mixture of amines	Silica and iron oxide from barite
					M						Amono-Phos	Crude mono-ammonium phosphate	
	P										Annite Reagent A	Amine soap	Oxidized minerals
		C									Armac TD (X)	Distilled primary tallow amine	Same as Armeen T plus potash
		C									Armeen C (X)	Primary Coco amine	Hematite, magnetite, ilmenite, wolframite, scheelite, monazite, chromite, feldspar, mica separattio
		C									Armeen HTD (X)	Distilled primary amine of hydrogenated tallow	Nonmetallics, mainly potash
		C									Armeen S (X)	Primary soya amine	Same as Armeen T
		C									Armeen SD (X)	Distilled primary soya amine	Same as Armeen T plus potash
		C									Armeen T (X)	Primary tallow amine	Silica, phosphate, feldspar, mica, spodumene beryl clay.

* *E&MJ* wishes to express its gratitude to Denver Equipment Co. The excellent table in Denver's Handbook is the basis for this compilation.

LEGEND

Fr Frother	Fc Flocculant	Fl General flotation	W Wetting agent
P Promoter	Di Dispersant	De Depressant	A Activator
C Collector	M Modifier		E Emulsifier

Fr	P	C	Fc	Di	M	Fl	De	W	A	E	Reagent and Mfr.	What It Is	Remarks
		C	Fc								Arquad 2C (X)	Dicoco-dimethyl ammonium chloride	Silica. Slime flocculation
		C				Fl					Arquad S (X)	Soya-trimethyl ammonium chloride	Collector silica. Float clays
					M						Barium Chloride	$BaCl_2$	Quartz
Fr		C									Barrett Flot. Oil No. 4	Coal tar creosote oil	Sulphides
	P				M						Barrett No. 410	Coal tar creosote oil	Sulphides, froth modifier
					M						Barrett No. 634	Coal tar creosote oil	Sulphides, for stiffer froth
	P										Castor Oil Acids 9–11	Distilled fatty acids of Castor oil	Oxides, nonmetallics
	P										Castor Oil Acids 135	Octadecadienoic acid	Oxides, nonmetallics
				Di	M						Caustic soda	NaOH	Alkalinity regulator
			Fc	Di							Cellulosics CMC (Z)	Sodium carboxy-methyl-celluose, ionic	Gangue slime depressant sulphide flotation
	P		Fc	Di							Cellulosics CMHEC (Z)	Carboxymethyl hydroxyethyl cellulose	Iron ore, nonmetallics
		C							A		Copper Sulphate	$CuSO_4 \cdot 5H_2O$	Sphalerite, arsenopyrite
Fr		C									Creosote Coal Tar		Sulphides, tough froth
Fr		C									Creosote No. 1 Hard-wood		Sulphides, gold flotation
Fr											Cresylic acid	Crude carbolic acid	Lead sulphides
							De				Cyanide	Sodium cyanide	Iron, zinc sulphides
				Di							Daxad No. 23 (Q)	Polymerized sodium salts of substituted benzoic alkyl sulfonic acids	Gangue slimes—pH 7–9.5
							De				Dichromate	$Na_2Cr_2O_7 \cdot 2H_2O$	Depress galena in Cu-Pb-Zn separations
Fr											Dowfroth 250 (V)	Watersoluble synthetic	Selective flotation
		C									Dresinate 7X1, 7V6 (Z)	Sodium soaps of rosin	Iron oxides, nonmetallics
		C									Dresinate 7Y1K (Z)	Potassium soap of rosin	Iron oxides, nonmetallics
		C	Fc								Duomeen S (X)	Diamine from soya	Nonmetallics, flocculation of slimes
		C	Fc								Duomeen T (X)	Diamine from tallow	Nonmetallics, flocculation of slimes
		C									Duponol 100 (M)	Sodium octyl sulphate	Molybdenite
		C									Elastoil LL' (L)	Linseed oil byproduct	Tungsten, nonmetallics
		C									Emcol X 25	Alkanolamine salt of a sulphated complex alcohol	Also used as emulsion with oleic acid, kerosene
						Fl					Emcol 4150	Fatty acid amite sulphate	Manganese
	P	C									Emersol 300 (K)	Distilled vegetable fatty acid	Fluorspar
							De				Ethyl Silicate	$(C_2H_5)_4SiO_4$	Gangue slimes in acid, neutral circuits where pH is critical
Fr											Eucalyptus Oil		Used in tropics
									A		Ferric Sulphate	$Fe_2(SO_4)_3 \cdot nH_2O$	Activates arsenopyrite, tetrahedrite in presence of cyanide, zinc sulphate. Floats minerals from sphalerite
Fr	P	C									Fish Oil, Fatty Acid		Anionic collector
						Fl					Flexricin 9 (J)	Propelene glycolmonoricinoleate	Oxides, nonmetallics
Fr											G & S No. 3 (T)	Pine Oil	
					M	Fl					Fuel Oil		Froth control
							De				Glue	Organic colloid	Slime regulator
			Fc								Galactasol	Guar gum	Slime flocculant
			Fc								Guartec (W)	Guar gum	Slime flocculant
				Di			De				Gum Arabic		Gangue slimes
							De				Goulac (H)	Calcium lignin-sulphate	Carbonaceous gangues, calcite, barite from fluorspar
							De				Hydrofluoric Acid	60% HF	Flotation of feldspar from quartz—depresses mica
	P	C									Indusoil (G)	Refined tall oil	Oxides, nonmetallics
								W			Invadine	Sodium alkylbenzene-sulfonate	
							De				Lactic Acid	C_3H_6O	Mica
									A		Lead Nitrate	$Pb(NO_3)_2$	Stibnite, sodium chloride from potash
					M		De				Lime	Calcium hydroxide	pH modifier, depresses pyrite

Flotation Reagents

(Letters in parentheses refer to these manufacturers.)

A Rohm & Haas Co.
B Union Carbide & Carbon Corp.
C Ciba Co.
D Oronite Chemical Co.
E Allied Chemical & Dye Corp.
F Marathon Corp.
G W. Va. Pulp & Paper Co.
H American Gum Products Co.
J Baker Castor Oil Co.
K Emery Industries Inc.
L Industrial Oil Products Corp.
M E. I. du Pont de Nemours & Co.
N Commercial Solvent Corp.
P Minerec Corp.
Q Dewey & Almy Chemical Co.
R Sharples Chemicals, Inc.
S American Cyanamid Co.
T Newport Industries, Inc.
U Pacific Lumber Co.
V Philadelphia Quartz Co.
W General Mills, Inc.
X Armour & Co.
Y Dow Chemical Co.
Z Hercules Powder Co.

Fr	P	C	Fc	Di	M	Fl	De	W	A	E	Reagent and Mfr.	What It Is	Remarks
			Fc								Lintz Reagent R-52	Surface active agent	
						Fl					Mahogany Sherosope F-445	Sodium salt of petroleumsulfonic acids	Metallic, oxide coppers, carbonaceous impurities from Pb-Zn ores
				Di							Marasperse (F)	Sodium ligno sulfonate	Phosphate flotation
Fr											Methyl Amyl Acetate		Brittle froth
Fr											Methyl Amyl Alcohol		Brittle froth
Fr											Methyl Isobutyl Carbinol		Selective flotation of sulphides, nonmetallics
				Di							Metso (V)	Sodium metasilicate pentahydrate	Gangue dispersant
						Fl					Micate	Soap from tall oil	Nonmetallics
	P										Minerec A (P)	Dixanthogen (diethyl dithiobis thionoformate	Acid or alkaline circuit. Excellent copper reagent
	P										Minerec B (P)	Dixanthogen (diethyl dithiobis thionoformate	Copper, gold in lime circuit
		C									Minerec 27 (P)	Similar to above	Selective, copper ores
Fr		C						W			Nacconol NR (E)	Sodium alkylated aryl sulfonate	Talc, nonmetallics
					M						Naphtha Solvent	Stoddard's solvent	Ilmenite, rutile, used with fatty acids
Fr	P										Naphthenic Acid D	Petroleum byproduct	Potash, barite, magnesite
Fr	P										Naphthenic Acid P	Petroleum byproduct	Potash, barite, magnesite
	P										Neo-Fat 8 (Caprylic Acid) (X)	Saturated fatty acid	For halite in potash separations
		C									Neo-Fat 42-06 (X)	Fractionate tall oil	Anionic collector for fluorspar, barite, beryl, magnetite, hematite, calcite, spodumene
		C									Neo-Fat 42-12 (X)	Fractionated tall oil, 12% rosin	Same as above
		C									Neo-Fat 94-04 (X)	Refined oleic acid	Same as above
		C									Neo-Fat 139 (X)	Refined cottonseed fatty acid	Same as above
	P	C									Oleic Acid		Nonmetallics, fluorspar
								W			Oronite Wetting Agent (D)	Petroleum byproduct	Nonmetallics
	P	C									Orso	Neutral soap	Scheelite, tungsten
Fr					M						Orthotoluidine	Black liquid	Froth modifier
							De				Palconate (U)	Sodium salt of phenolic acid	Depresses calcite in flotation of fluorspar and scheelite.
							De				Palcotan (U)	Sodium salt of sulfonated organic acids	Same as above
Fr					M						Pentasol Frother 26 (R)	Amyl alcohol	Froth modifier
Fr										●	Pentasol Frother 124 (R)	Mixed amyl alcohols	
							De				Potassium Permanganate	$KMnO_4$	Selective sulphides
							De				Quebracho	70% tannic acid	Calcite in fluorspar, wolframite in sulphides
	P										Reagent 301 (S)	Xanthate, higher petroleum alcohol	Sulphides, oxidized base metals after sulphidizing
	P										Reagent 322 (S)	See above	Sulphide minerals
	P										Reagent 325 (S)	Xanthate, lower alcohol than 301	Sulphides, bulk flot.
	P										Reagent 343 (S)	Similar to 301	All sulphide minerals
	P					Fl					Reagent 404 (S)	Mercaptobenzthiazole	Oxidized base metals, float vanadium, auriferous pyrite ores
	P					Fl					Reagent 425 (S)		Oxidized copper ores, promoter for malachite, azurite
	P										Reagent 444 (S)		Cu, Zn sulphides
				Di							Reagent 610 (S)		Gangue dispersant
							De				Reagent 645 (S)		Carbonaceous gangue, As, Sb sulphides
	P	C									Reagent 710 (S)	Vegetable fatty acid	Phosphate, fluorspar, barite
Fr	P										Reagent 712 (S)		Floats middlings
		C									RADA (Z)	Rosin amine D acetate	Silica, silicates—used beneficiating feldspar, phosphate, quartz

Fr	P	C	Fc	Di	M	Fl	De	W	A	E	Reagent and Mfr.	What It Is	Remarks
	P										Reagent 801 (S)	Petroleum sulfonic acids	Nonmetallics, calcite, barite, tungsten, garnet, iron ores
	P										Reagent 825 (S)	Similar to 801	Similar to 801, more selective on some ores
	P	C									Red Oil	Oleic-linoleic acids	Anionic collector
	P					Fl					Sapamine (C)	Cationic reagent	Promoter floating silica from gypsum. Float iron ores
					M						Soda Ash	Na_2CO_3	Alkalinity regulator
							De				Sodium Bisulphite	$Na_2S_2O_5$	Fe, Zn sulphides
							De				Sodium Ferrocyanide	$Na_4Fe(CN)_6 \cdot 10H_2O$	Sulphides, selective—used to float molybdenite from bulk Cu conc.
			Fc								Separan 2610 (Y)	Synthetic Organic	
						Fl					Sodium Fluoride	NaF	Nonmetallics, ilmenite, fluorspar
							De				Sodium Hydrosulphite	$NaHSO_2$	Fe, Zn sulphides
	P										Sodium Oleate	Fatty acid soap	Oxides, nonmetallics
							De				Sodium Silicates (V)		Siliceous gangue minerals, gangue slimes
							De				Sodium Silicofluoride	Na_2SiF_6	Quartz, feldspar in spodumene flotation
							De				Sodium Sulphide	$Na_2S \cdot 9H_2O$	Au, silver sulphides
							De				Sodium Sulphite	Na_2SO_3	Fe, Zn sulphides
				Di			De				Sodium Tetra Pyrophosphate	$Na_4P_2O_7 \cdot 10H_2O$	Depress calcite in flot. of magnesite.
			Fc				De				Starch		Depress slime in sulphide flot.
							De		A		Sulphuric Acid	H_2SO_4	Reactivate pyrite after depressing with lime, cyanide—Depresses quartz
Fr	P										Syntex L	Sulphated monoglyceride of cocoanut oil derivation	Molybdenite
		C									Sonneborn Reagents 1, 2, 3	Petroleum sulfonates	Phosphate, barite, feldspar, fluorspar, manganese oxides
							De				Tannic Acid	Tannin C76H52046	Calcite
	P	C									Tall Oil	See Indusoil	Nonmetallics
Fr		C						W			Tergitol Penetrant No. 4 (B)	Sodium lauryl sulphate	Non-sulphide flotation
Fr		C						W			Tergitol Wetting Agent No. 7 (B)	Surface active wetting agent	Non-sulphide flotation
Fr											Terposol No. 3 (Z)	Terpinyl methyl ethers and terpene alcohols	
Fr											Tertiary Amyl Alcohol (R)		
	P										Thiocarbanilide		Pb, Zn, Cu, Ag ores—selective flot. of sulphide
	P										Thiocarbanilide 130		Same as above but more dispersable
			Fc								Tragacine Powdafloc	Starch base powder	Settlement of slimes
				Di			De				Tri-Sodium Phosphate	$Na_3PO_4 \cdot 12H_2O$	Alkaline detergent
		C									Triton K-60 (A)	Dimethyl cetyl benzyl ammonium chloride	Nonmetallics, cationic
		C									Trostol	Rosin and fatty acids	Nonmetallics
	P										TT Mixture	Dissolve not more than 15% thiocarbanilide in hot orthotoluidine	Pb, Cu, Ag ores
Fr	P										Turkey Red Oil	Sulphated, sulfonated castor oil	Nonmetallics
Fr		C		Di				W			Ultrawet DS	Sodium alkyl aryl sulfonate 85% active	Good frother, collector for talc, steatite
Fr		C		Di				W			Ultrawet 30DS	Aqueous solution of above	Same as above
						Fl					Vapor Oil	Hydrocarbon oil	Molybdenite
							De				Wattle Bark Extract	Tannin similar to Quebracho	Calcite
		C									Xanthate Z-3 (Y)	Potassium ethyl xanthate	Bulk flot. of complex sulphides
		C									Xanthate Z-4 (Y)	Sodium ethyl xanthate	Same as Z-3
		C	Fc								Xanthate Z-5 (Y)	Potassium sec amyl xanthate	Slow floating, semi-oxidized sulphides
		C									Xanthate Z-6 (Y)	Potassium amyl xanthate	Gold, arsenopyrite, slow floating sulphides
		C									Xanthate Z-8 (Y)	Potassium sec butyl	Tarnished sulphide minerals or metallics
		C									Xanthate Z-9 (Y)	Potassium isopropyl xanthate	Pb-Zn-Fe sulphide ores
						Fl					Xanthate Z-11 (Y)	Sodium isopropyl xanthate	Pb-Zn selective flot.
Fr											Yarmor F (Z)	Pine oil	Sulphide minerals
							De				Yellow Dextrine	Starch product	Slime depressant in flot. of sulphides
							De				Zinc Hydrosulphite		Zn, Fe sulphides
							De				Zinc Sulphate		Pyrite, sphalerite in selective flot. of Pb, Zn, Cu ores

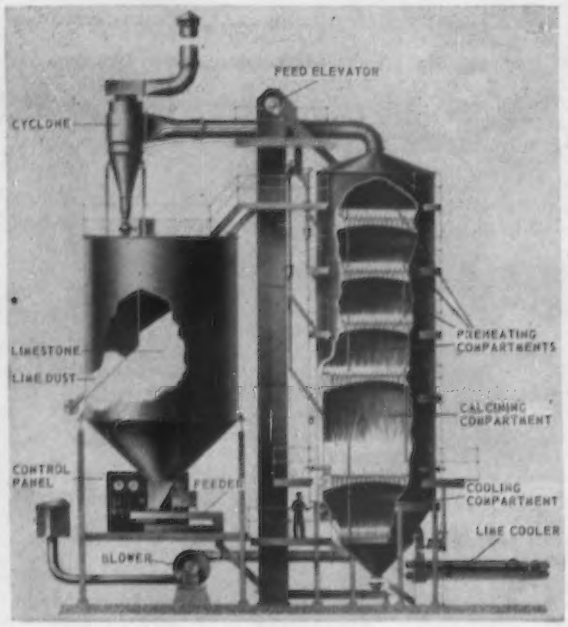

FIG. 1. MULTIPLE COMPARTMENT reactor for calcining.

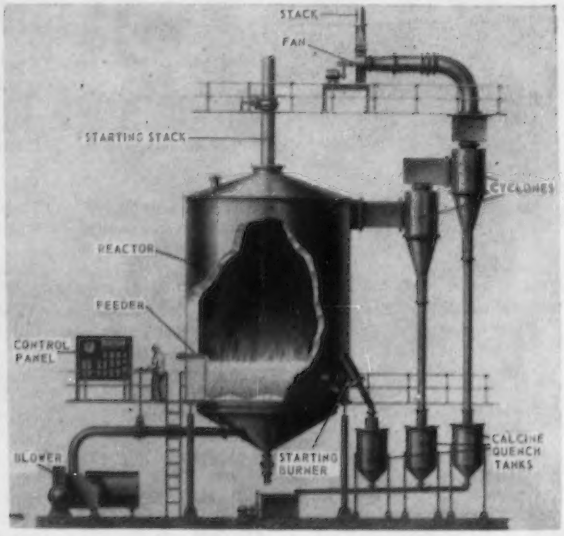

FIG. 2. DORRCO FLUOSOLIDS single-compartment reactor has proven effective in roasting arsenical gold ores to increase gold extraction by cyanidation. Installations like this are now treating gold-bearing ores and concentrates in the U.S. and Canada where low-temperature roasting was desired.

How Fluidization Can Serve The Mineral Industries

THEODORE B. COUNSELMAN

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FLUIDIZATION TECHNIQUE is a new tool in the metallurgical and other industries. It is thoroughly established in the petroleum industry, where it originated, for continuous catalytic cracking of petroleum vapors. There, it enabled this country to produce the large quantities of high test aviation gasoline needed in World War II and subsequent military and commercial operations. The Dorr Co. was licensed by Standard Oil Development Co. to exploit this fluidization technique in non-petroleum, non-fuel applications. Dorr gave this operation the distinctive trade mark of "FluoSolids."

After five years of experimental research on the entirely new problems involved, the first commercial installation of FluoSolids was made in 1947. There are, as of Jan. 1, 1955, a total of about 75 FluoSolids reactors in operation or under construction all over the world. Currently nearly one million tons of 100% sulphuric acid is being produced per year from SO_2 gas generated in FluoSolids reactors; a total of over 80,000 tons of zinc metal per year from concentrate roasted by FluoSolids systems for further treatment, either by pyrometallurgical or electrowinning methods; a total of 700,000 tons of paper pulp per year produced by the sulphite process, the SO_2 gas for the production of the bi-sulphite cooking acid having been produced in FluoSolids reactors from pyrite or pyrrhotite; as well as many miscellaneous applications.

It is time to take a look at the record of what has been accomplished, the successes and the failures; to make a prognosis of the foreseeable future for this new unit operation.

Fluidization technique is the partial suspension of solid particles in a stream of gas. To be so suspended, the particles must be finer than some limiting size, which will depend on the gas velocity used and the specific gravity of the solids. When the solids are properly fluidized, the mixture of solids and gases is very uniform and behaves like a liquid. The mixture will seek its own level, will overflow weirs, will exert hydrostatic pressure and its flow may be controlled by suitable valving.

Each partially suspended solid particle tends to be surrounded by a constantly changing film of gas. This makes possible the intimate contact necessary for solids-gaseous reactions. Where heat is involved, either exothermic or endothermic, a reverberatory condition between particles obtains. Because of the violent movement of the particles in a fluidized bed, this leads to almost perfectly uniform temperature conditions in the bed (as may be observed by random thermocouples) and excellent heat transfer conditions. By the use of properly instrumented automatic controls, such as the introduction of water into the bed to take advantage of Btu absorption by latent heat; by recycling of cooled gases into the bed below the surface (or into the freeboard); by sprays in the freeboard; by cooling coils or jackets in the bed; by control of feed rate;

by return of sulphated fines for breaking down the sulphate; or, in the case of endothermic reactions, by controlled metering of the fuel or the combustion air or both; the temperature of the bed can be accurately controlled within ten or twenty degrees. This is most important for the carrying out of certain reactions, such as sulphating of copper sulphides; for minimizing ferrite formation in dead roasting copper or zinc sulphides; for drying surface moisture from combustible materials, such as coal; for driving off combined moisture; for such reactions as the magnetic conversion of iron oxides; and so on.

Also, by proper control of the fluidizing air or other gases admitted to the gas tight reactor, the composition of the gaseous atmosphere can be accurately controlled. Thus, with all of these controls, FluoSolids reactors, suitably instrumentized, can be operated from the control panel and to a large degree, entirely automatically, with only casual supervision.

Why Maintenance Costs Are Low

All of this, plus the absence of moving parts in the high temperature areas ensuring low maintenance costs, gives an entirely new field of possibilities in roasting. Things can be accomplished by this technique which were not formerly possible. In roasting sulphides, for instance, higher gas strengths are obtainable than by other methods of roasting, approaching closely to the theoretical. This is extremely important in making bi-sulphite cooking acid for sulphite paper mills. In the roasting of gold ores, arsenic can be driven off, and the sulphur can then be roasted out of the pyrite; or the telluride can be broken down; resulting, by close control, in the optimum gold recovery by cyanidation. Temperature of roasting, and conditions of the roast, play a most important part here, and desired results are possible to better advantage by FluoSolids roasting than by other roasting methods.

In roasting of pyrite for its sulphur content for making sulphuric acid, it is frequently desired to utilize the resulting high grade iron oxide for steel making. Only too often, the iron oxide calcine contains small amounts of base metals such as copper, zinc, and lead, or other elements such as arsenic, which interfere with such use. Conventional methods of roasting with their lack of control of particle temperature, usually succeed in fixing such elements, possibly as ferrites or other complex compounds, so that their removal can be accomplished only by means of the expensive step of a second, chloridizing roast. It is frequently possible, by the fluidization technique with its accurate controls, to solubilize some of the elements, and volatilize others, so that desired specifications can be met.

These are some of the characteristics and possibilities of fluidization. Now for the record of what has been accomplished.

One of the early commercial installations was for calcining limestone. A single 100 ton per day (of CaO) installation is operating very successfully. A multiple compartment reactor, as illustrated (Fig. 1), is required to obtain fuel economy. This reactor has five compartments, one above the other. Fuel is introduced in the next to the bottom compartment. The three upper compartments are for heat recovery, heat from the gases of combustion and released carbon dioxide being transferred to the incoming raw stone; and the bottom compartment is also for heat transfer, the fluidizing air being preheated by the hot burned lime which is thus partially cooled.

Fuel for this installation is Bunker C oil. It is pumped into the reactor by means of piston pumps through a series of air-cooled burners equally spaced around the periphery of the combustion compartment and extending approximately 18 in. inside of the brickwork. The oil is not atomized, each burner being connected to a single pump body, and the oil being introduced in spurts. Presumably it coats, momentarily, the surface of the white hot particles of burned lime in the bed, being instantly vaporized and burned. Violent movement of the fluidized bed distributes heat uniformly. Temperature is controlled by varying ratio of feed to oil. Gas could also be used as fuel, and some continuous pilot-plant runs have been made using powdered coal.

The quality of the burned lime, using oil for fuel is excellent, and superior to the quality of lime produced from the same stone in a rotary kiln. Yield, color, availability, slacking characteristics, are all better, and customers demand FluoSolids lime in preference to rotary kiln lime. Heat requirements for FluoSolids lime, from this particular stone, are between 4½- and 5-million Btu per ton of burned lime. A shaft kiln normally takes 4 to 6 million, and a rotary kiln, long enough to be economic, from 8- to 12-million Btu per ton. Shaft kilns cannot handle fine sizes, below 2 in. or so, and rotary kilns do better if everything in the feed below ⅜ in. to ¾ in. is screened out. These finer sizes must be wasted.

Application of FluoSolids to lime calcination has been found to be somewhat special. Hard, crystalline limestones which decrepitate or abrade to a minimum degree are preferred. Also Bunker C oil is preferred as fuel, although gas and coal could probably be used if necessary. Further development work might be required.

Fluidization Increases Gold

The next installation of importance was the roasting of arsenical gold ores, to increase gold extraction by cyanidation. After much experimentation to find correct roasting conditions, a small commercial unit was installed in Canada. In general, the ore was cyanided, pyrite floated out of the tailing and this concentrate roasted to get rid of the arsenic and the sulphur, and make the calcine porous, for penetration of cyanide solutions. Results were successful, except for the difficulty of feeding sticky filter cake to the reactor. This difficulty was overcome by repulping the filter cake and feeding the material to the reactor in the form of a slurry, at about 80% solids. Roasting was desired at a fairly low temperature for best gold extraction, and under neither reducing nor highly oxidizing conditions. The heat balance was such that the amount of water present in the 80% solids slurry was still insufficient to control the temperature to the desired figure and a further increment of water could be added, under thermostatic control. A single compartment reactor is shown in Fig. 2.

This first installation led to two more in the Red Lake district in Canada, then to one at the Golden Cycle mill in the Cripple Creek, Colo., district. Where the arsenic content is higher and cannot be satisfactorily removed in a single compartment reactor, a split-compartment reactor, as illustrated (Fig. 3) is used, in which a vertical division wall creates two compartments. Raw feed is partially roasted in the first compartment, with a deficiency of air. Arsenic is volatilized as sulphide, with the burning of only a portion of the sulphur. Partially roasted calcine transfers automatically to the second compartment where the roast is completed with an excess of air. This gives the roasting conditions which are most favorable for gold extraction, and with lowest cyanide and lime consumption. Two reactors of this type have been installed in Canada, one in South America and one in South Africa.

The upsurge in the use of FluoSolids roasting came with

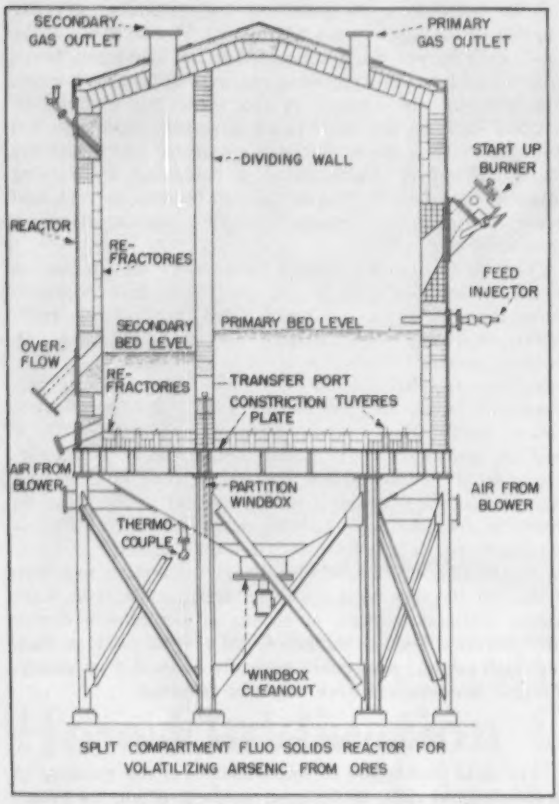


FIG. 3. SPLIT-COMPARTMENT UNIT is used when arsenic content of gold ores is too high for treatment in single compartment.

the shortage, in 1951-1952, of sulphur as brimstone in the United States; and with the demand for sulphuric acid for uranium extraction in South Africa. The source of sulphur there was from pyrite floated out of the cyanide tailing from the gold mines of the Witwatersrand. In the United States, rather than be forced to curtail production, many companies put in FluoSolids roasters to get SO_2 from various sulphides, notably pyrite and zinc sulphide. This was accomplished by using flotation concentrate of pyrite, or pyrrhotite in some cases, floated out of the tailing of base metal concentrators; and in some cases the flotation concentrate of the base metal itself. This concentrate was made into a thick slurry to break down any frozen or sticky lumps, and pumped into the appropriate size FluoSolids reactor at a properly controlled rate of feed. In one case where an additional amount of SO_2 gas was wanted, a small amount of brimstone was added to the pyrrhotite feed, bringing the total sulphur in the feed up to the equivalent of pyrite. In another case, the pyrite is pelletized and fed dry to a special two compartment FluoSolids reactor. This pelletizing minimizes the dust carryover.

In some cases, the desired product was sulphuric acid, usually produced by the conventional contact acid plant. Where pyrite was used as raw material, the calcine was sometimes used for steel making, in other cases sold to cement plants, or for other uses, or wasted (See Fig. 4). The other big use for SO_2 gas was in making cooking acids for paper making by the sulphite process. The fluidization technique is particularly useful for this purpose, because it produces such strong SO_2 gas. Paper mills are accustomed

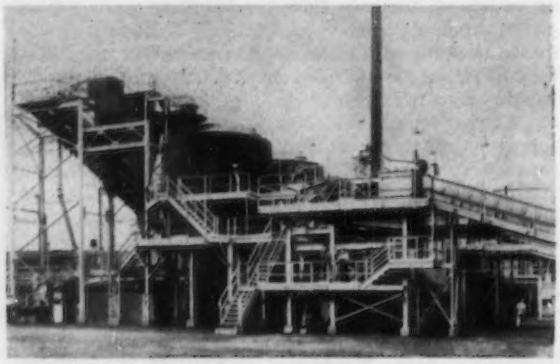


FIG. 4. THIS REACTOR produces SO_2 gas for sulphuric acid, and a high-iron calcine for the production of steel.

to burning brimstone and getting 15 to 16% SO_2. This they absorb either in limestone towers to make calcium bi-sulphite acid, or in soda ash solution, or they make a magnesia basic acid depending on the quality of paper desired. FluoSolids roasters from a pyrite carrying 48% sulphur will make about 15% to 15¾% SO_2 without difficulty. Other methods of roasting, flash, or multiple hearth, will produce 9% to 11% SO_2 as a maximum. This strength gas, with the inevitable dilutions, can be used for contact sulphuric acid, but not very readily for cooking acid in a paper mill. With this lower strength gas, volumes are greater and cleaning equipment, cyclones, Cottrells, scrubbers, etc., are larger and more expensive and the strength of the finished cooking acid is affected adversely.

Water vapor present in the gas, resulting from the use of slurry feed and water control of temperature, makes no particular difference in the case of contact sulphuric acid or for cooking acid for a paper mill, except for the larger gas volume. In each case, the gas is scrubbed and cooled, so that it is always saturated and at about 100 deg F when used. Any excess water is condensed out, and the only problem is the loss of SO_2 dissolved in this water. A stripping tower will take care of that.

FluoSolids for Chamber Acid Plant

In the case of a chamber acid plant there has heretofore been some question as to water vapor. The gas is used hot so a scrubber is not permissible. Water is added at various points in the lead chamber or tower system and it was thought for a while that this might make water vapor undesirable in the gas. A water balance indicated that the amount of water vapor in the gas from the FluoSolids reactor was within permissible limits, but would reduce the amount of water which could be added at various points along the system. Finally, a full scale test on a commercial chamber acid plant was made in which steam was added to the gas in amounts equivalent to that which would result from slurry feed and water control of temperature. The results were entirely satisfactory. Enough water could still be added at necessary points in the chamber system; 60 deg Baume acid was easily produced, just as usual and there was no increase in nitre consumption. No commercial installation of a FluoSolids system with slurry feed has as yet been made in connection with a chamber acid plant (nor a Petersen tower plant) but one is scheduled in the future.

There is, however, an installation of a FluoSolids system in connection with a chamber acid plant in which dry feed

is used, and temperature control is obtained with excess air. This reduces gas strength but not below the acceptable ratio of sulphur dioxide to oxygen.

It is of course possible to recover waste heat from the gases from a FluoSolids unit and there are several installations where this is being accomplished very satisfactorily. Usually gases from the reactor go directly into the waste-heat boiler, to recover maximum amount of heat (See Fig. 5). In some cases it could be desirable, as in pyrite roasting, to interpose a cyclone, which would have to be refractory lined of course, to take out coarser solids. This would minimize abrasion of boiler tubes.

There has been great discussion about the necessity of dry feed, and temperature control by other than water addition, when maximum steam production is desired. It is true that more steam can be produced with dry feed, about 1.4 lb per pound of 48% sulphur pyrite with dry feed, as against about 1 lb for slurry feed, but the economic facts are these. If temperature control is by coils in the bed, through which water is pumped, the heat taken up by the water is not recoverable because it is low potential heat. If the bed is controlled to the same temperature, no more heat is recovered in the steam than by water addition, neglecting the volume of steam in the gas. If the coils are used to produce steam as part of the boiler, on the Lamont system, then the unit becomes rather inflexible. In the USA it must then be operated by a licensed steam engineer and the insurance rates must be considered. If temperature control is by recycling cooled gas, the overall costs involved, of a difficult fan or blower problem, cost of drying the feed, and fixed charges on the extra investment, add up to more than the value of the extra steam recovered. This is true under the normal American valuation of 50c per thousand pounds of steam. For European conditions where a higher value is placed on the steam, roughly $1.25 per thousand pounds, it is of course desirable to produce the maximum amount of steam, somewhat regardless of first cost. Local considerations govern in each case.

Applications in Zinc Metallurgy

Several FluoSolids units are installed for roasting zinc concentrate. When roasting for electrolytic zinc operations, it is usually not difficult, even on a high iron concentrate, to get residual sulphurs in the calcine of 0.1% to 0.3% sulphide and 1.0% to 1.5% total sulphur. But the outstanding advantage of FluoSolids roasting is that it will produce a gas strength of 11% SO_2. This is very desirable, compared to other forms of roasters. Also the calcine from such a roasting operation has been found to have greater solubilities, in spent cell liquor and acid of zinc, cadmium and copper. These are all very desirable characteristics.

Zinc flotation concentrate may also be roasted for sintering with subsequent production of metal by one of the retort processes. In such cases it is frequently desirable to leave sufficient sulphur in the calcine to serve as fuel in sintering, and enough sulphate must be present to facilitate sintering. The calcine can be roasted to contain the desired amount of sulphate, or this can be added just ahead of sintering as zinc sulphate from cadmium recovery operations or other sources. Whether sulphur or coal or coke is used as fuel for the sintering depends on local conditions. It is possible in FluoSolids roasting to leave any desired amount of sulphur in the calcine. This is accomplished by suitable control of the amount of excess air introduced into the reactor.

The gas resulting from zinc roasting must be cooled quickly to prevent the formation of scale in the ducts or cyclones. Since some of the zinc, cadmium, etc., is converted into sulphates in small amounts, scrubbers cannot be used on the gas until substantially all of the solids are removed. The gas cannot go to cyclones directly, or even be conducted through very long ducts. It should go either to a waste heat boiler or to a gas cooler, with just as short duct connections as possible. A hot Cottrell following the waste heat boiler or gas cooler is usually desirable though not always necessary; however, the gas must be cooled to 1,000 deg F or less, ahead of the Cottrell.

Applications in Copper Metallurgy

Roasting of copper sulphides can have several different objectives. A dead roast may be desired and some experimental work has been done successfully along this line. Customary smelting practice involves feeding copper concentrate to a reverberatory furnace, and for this purpose the sulphur in the copper concentrate must be reduced to about 15% (depending on practice at that smelter). This is a partial roast and sometimes requires extraneous heat, since there are frequently not enough excess sulphur units to supply the necessary heat. It has been demonstrated, however, that such partial roasting is entirely feasible by fluidization. About a 12% SO_2 gas results from such a roast.

A sulphating roast of copper sulphide concentrate is attractive for many reasons. The copper is made water-soluble and weak-acid-soluble, and can be recovered from solution by electrowinning, without first smelting and subsequent electrolytic refining. Gold and silver values remain with the calcine and must be recovered by cyanidation. Electric power required for copper deposition is ten times as much with insoluble anodes, as with soluble anodes. In the past, too much iron went into solution with the copper, making purification of solutions difficult and the whole operation uneconomic.

FluoSolids roasting solubilizes copper, sometimes up to 98 or 99%, while only solubilizing 3 or 4% of the iron. This gives a totally different picture to the solubilizing and electrowinning of copper. Now the solution can be purified without too much difficulty. Extra acid produced in the electrolytic cells can be used in leaching oxide copper from the overburden or from oxide ore from certain parts of the mine which oxide ore is generally not fully recovered.

Another possibility is the treatment of copper-zinc concentrate, where the two metals cannot adequately be separated by flotation. At Dowa Mining Co., Japan, a mixed copper-zinc concentrate is produced, which is roasted to solubilize both the copper and zinc. After suitable purification, each is recovered electrolytically. Before FluoSolids roasting was introduced, the zinc could not be recovered but went into the slag of the copper smelter.

Tail liquors from electrowinning of copper operations, which must be wasted to maintain the acid balance, and cannot be further used for leaching oxide copper, can be run over scrap iron, producing cement copper. This can either go to the smelter, or it can be charged back into the reactor, thus finally reporting as electrolytic copper.

Cobalt can be solubilized with copper and recovered electrolytically, or the concentrate can be subjected to baking at suitable temperatures which will permit depressing copper and floating out a much higher grade cobalt concentrate for subsequent recovery operations. Molybdenum can be separated from copper in the same manner. All three of these have been explored experimentally and pilot operations preliminary to commercial installations are going on with the first two, for cobalt recovery.

In the production of titanium metal, one of the steps is

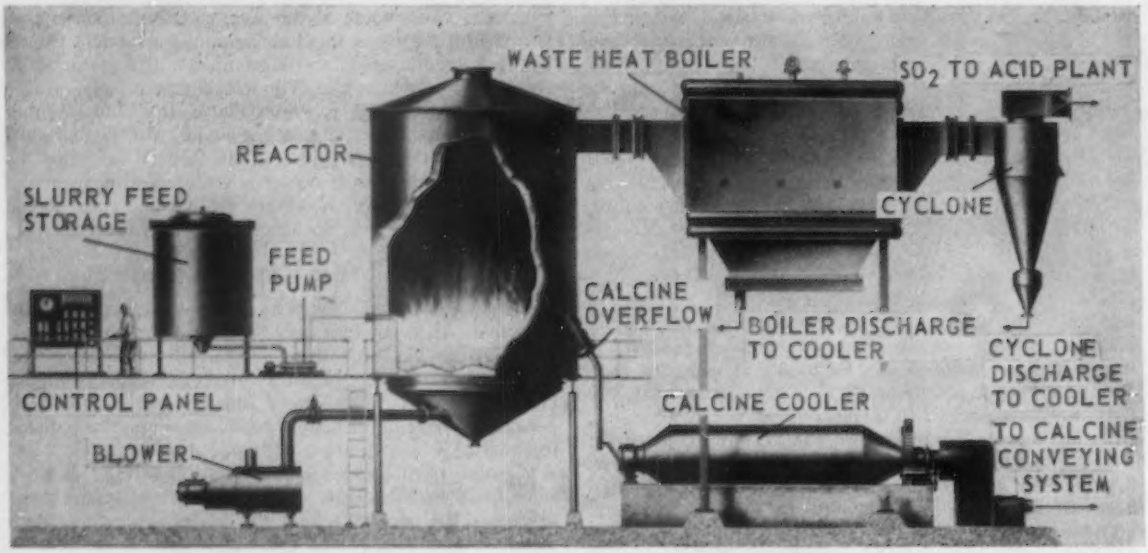


FIG. 5. SINGLE-COMPARTMENT REACTOR with waste-heat boiler roasts zinc concentrates to produce SO_2 gas for contact sulphuric acid plant, and a calcine for an electrolytic zinc plant. Gas strength produced runs about 11% SO_2.

to produce titanium tetrachloride. This has been done very successfully in test work and also in a fair sized pilot plant in FluoSolids reactors. Intensive work along this line is now under way. Fluidizing is carried out with chlorine gas instead of air.

Fluidized roasting with chlorine gas is used to upgrade chrome concentrates. When chrome-iron ratios are below the desired three-to-one for making ferrochrome, a portion of the concentrate can be subjected to a chloridizing roast. The iron will be attacked first, and volatized off as ferric chloride, thus enriching the chrome value of the portion so treated. A sufficient fraction of the concentrate can be treated so that the mixture of the untreated portion and the upgraded fraction will have the desired ratio. The ferric chloride, theoretically, can be condensed out of the exit gas and burned in an inert fluidized bed, say of sand, to liberate chlorine for reuse. Iron oxide, in very finely divided form, would be a by-product. This has been successfully accomplished on a laboratory test scale but not yet applied to commercial operations.

Extraction of Native Sulphur

Much volcanic or secondary native sulphur near the surface, is scattered around the world. Many attempts have been made to develop commercial processes to win elemental sulphur from these ores which average about 30% sulphur with wide variations. The difficulty has been to get a high yield and a high purity. Of course the methods used to get brimstone from secondary sulphur ores in Sicily could be used but improved recoveries are to be desired, Of the various methods which have been publicized, recoveries are about 85% and the purity of the sulphur is only 90 to about 95%. This presents a serious purification problem.

If the operation will stand the freight rates, it is simpler to dry crush the sulphur ore, or prepare a flotation concentrate therefrom, which will stand considerable shipment, and feed this to a FluoSolids reactor. A strong SO_2 gas can be made in this fashion for sulphuric acid production or other uses. Such a plant is in operation by Anaconda at Yerington, Nev. (See Fig. 6.) Native sulphur ore carrying 25 to 35% sulphur (dependent on how mining is conducted) is dry crushed to nominally 10 mesh, actually coarser, and fed dry to three of four 18-ft reactors. Gas strength is held down to 12% though a higher strength has been demonstrated, up to 16 or 18%, without difficulty. It is important not to get the strength too high for fear of elemental sulphur depositing out in the gas cleaning system. One of the difficult things which had to be overcome was the extreme decrepitation of the gangue of this volcanic ore. Some 30% of the calcine was finer than 5 microns. This led to a difficult gas cleaning problem which was solved.

How About Elemental Sulphur?

Elemental sulphur from pyrite should be mentioned here. A certain amount of work has been done to recover the labile atom. Theoretically it is possible, although the gas cleaning problem, before permitting the sulphur to condense from its gaseous state, is serious and will be difficult to solve. Obviously, a scrubber cannot be used. The principal difficulties, however, are economic. Only about a third of the total sulphur in the pyrite can be so recovered. The rest of the sulphur reports as SO_2 gas. Unless this can be used, the cost of the elemental sulphur produced becomes too high. If pyrite, at 48% sulphur, can be purchased for about $10 a ton unloaded at point of use, and if the SO_2 gas is wasted to atmosphere, and if there is no credit for the iron oxide calcine, then the elemental sulphur produced will cost upward of $60 a ton. With Frasch process brimstone available at about $30, the circumstances must be rather special to justify an operation to recover the labile atom of sulphur. Preferably, use must be made of the SO_2 gas, and there must be a market for the calcine. In places where the pyrite can be laid down for $10 a ton, you are generally a long way from a market for sulphuric acid for liquid SO_2, or for iron ore.

Another source of SO_2 for acid making around steel plants is waste pickle liquor. Presumably, the heptahydrate can be used instead of water to slurry a pyrite feed and as cooling water to a reactor, if that method of temperature

control is used (severe corrosion must be overcome). The water balance becomes somewhat difficult. It would be easier to use the mono or dihydrate, or something in between. Either one of these can be fed with pyrite to furnish the required heat, either slurry or dry feed. Btu's are required to break down the sulphate and release SO_2, so that this material helps with temperature control. The iron oxide from the operation joins, of course, the pyrite calcine. In a steel plant, this material would go to the sintering plant and thence to the blast furnace. If consumed in this way, the present serious waste disposal problem of the pickle liquor would be solved. Considerable work has been done in the laboratory on feeding mono or dihydrate to a pyrite roasting operation, and one plant has been built which includes this possibility, though it is not now being practiced.

In limestone calcination, shaft kilns must use lump stone about 6 in. in size. Finer stone must be wasted. Some stones decrepitate to such a degree that they cannot be calcined in a shaft kiln. The stone decrepitates and slumps on the grates, blocking the draft. Such stones must be calcined by rotary kilns, and even here it is desirable to screen out material finer than some limiting size such as ⅜ in. This has resulted in piles of these rejected fines around lime plants. The material has a value if dried, and FluoSolids reactors have proved to be an excellent way to dry it. Material as coarse as ¼ in. can be dried at temperatures below the calcination point, and at the same time these fines can be dry classified at about 100 mesh, effectively. Three installations are doing this with success and a fourth is about to start. Firing in a dutch oven is used to furnish hot air at the desired temperature.

Interest Grows in Half-Burning Magnesia

Half burning of dolomite is also practiced, the magnesia being calcined without touching the calcium carbonate. The magnesia has various attractive uses and there is a growing interest in this operation.

Another big potential field of application for fluidization is in the drying of the fine sizes of coal. Often these finer sizes are wasted now because all the present dryers on the market have various shortcomings. A fairly good sized FluoSolids pilot plant has been in operation for six months or so in this field reducing moisture after centrifuges from more than 11% to less than 3%. While hot air at 1600 deg F is used to fluidize coal, coal particles themselves do not get hot enough to start oxidizing. Some details remain to be worked out in this application.

In addition to drying operations on limestone fines and coal, and baking operations to assist in recovery of cobalt and molybdenum, it has been found that a baking treatment of uranium ores in many instances increases extractions. Presumably this is by breaking down colloidal conditions. Anyway, this practice seems to be established, and fluidization with its close controls offers many advantages. Other applications in the treatment of uranium ores are classified information.

Drying operations mentioned above all involve removal of surface moisture. Combined moisture also can be removed if desired and in some cases this is current practice. One instance in the United States is calcining of aluminum hydrate to alumina, on which a great deal of work has been done, first in the laboratory and subsequently in a small multi-compartment pilot reactor. A similar example is the calcining of magnesium hydrate to the oxide. By temperature control the degree of activity in hydration can be controlled.

Another interesting application of fluidization is the

FIG. 6. FOUR SINGLE-COMPARTMENT FluoSolids reactors roast low-grade native sulphur to produce SO_2 for acid plant.

volatilization of tin. It is extremely difficult to concentrate the low grade tin ores of Bolivia because of the extremely fine grinding required for liberation, the friable nature of the tin minerals, and the rather poor results from flotation of these various oxides.

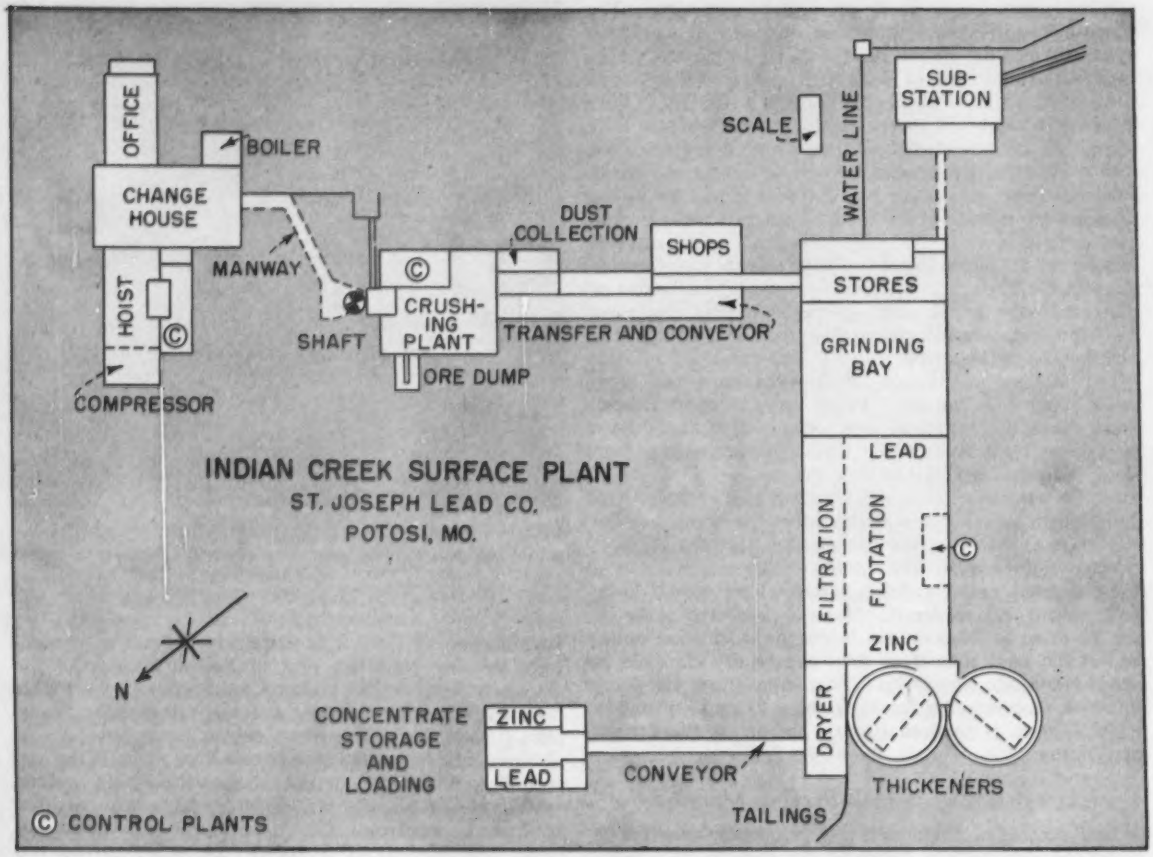
It has been found that by adding a little pyrite to the ore, ground to fluidizing but not liberation size, tin can be volatilized as a tin sulphide. Then by introducing air into an upper compartment, the tin can be burned back to an oxide, and the heat so produced used to preheat the ore up to reaction temperatures. The tin oxide is then carried out by the gas stream and can be recovered therefrom by conventional methods.

Considerable work is in progress on various interesting potential applications for fluidization such as drying plastics, or other materials where close temperature control is a requisite. Some work has been done on drying sand, and also in drying spent foundry sand and burning off the carbon. This could be important in a steel foundry. Some thought has been given to reburning bone char used to bleach corn sugar syrup and so on. Experimental work has been done on carbon activation. Quite a little time was spent on producing plaster of paris from gypsum. Present methods with conventional gypsum kettles are an art rather than a science and it is believed that the close control made possible by fluidization should enable continuous production of specification material. The market is rather large and while considerable testwork has been done, more urgent applications have prevented carrying this work through to a successful conclusion.

Possibilities in the Phosphate Industry

Drying of phosphate rock concentrates is a large tonnage operation which has been studied, and it is believed that fluidization can be successfully applied here. There is also the possible application of defluorinating phosphate rock (and certain other materials). It has generally been considered that the temperatures required for defluorinating such materials were beyond the present permissible limits for FluoSolids reactors, usually considered to be about 1,000 deg C. The reason is simply a matter of

(Continued on p 96)



What Goes Into Modern Mill Design

Change house features include radiant heating, a floor finished with anti-bacterial cement for the prevention of athlete's foot and recessed lockers which eliminate fire hazard and bad housekeeping tendencies because it's impossible to pile anything on top of them. Scattered wash-up facilities are only a short walk from any locker, and shower stalls are low enough to give men full view of lockers while bathing. Tunnel to shaft collar lets men enter mine without going outdoors.

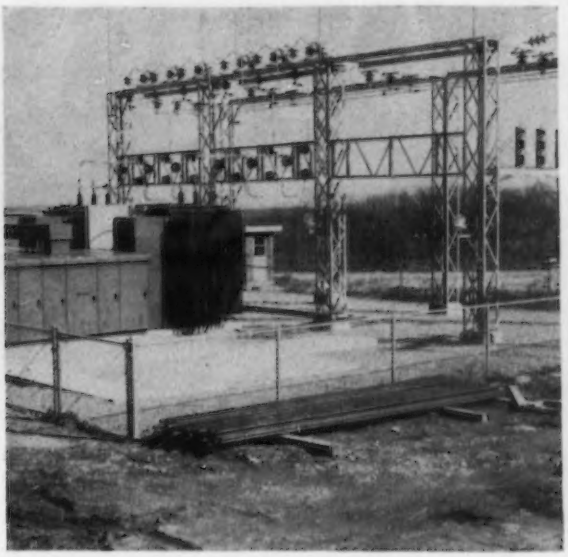
C. KREMER BAIN
Consulting Engineer

MODERN DESIGN shows up in two ways at St. Joseph Lead Co.'s Indian Creek mill; in concern for today's convenience and in provision for tomorrow's expansion.

Hoist and crushing plant were designed to handle 2,000 tons of ore in 6½ hours, with an ore bin large enough to treat 2,000 tons in 24 hours. Looking forward to possible increase in plant capacity, the mill was laid out so that capacity could be doubled by duplicating the grinding and flotation section on the southwest side of the present building without any changes in the crushing plant, bin capacity or concentrate end. With this in view, all main power cables for the concentrator were run in trenches along the south wall of the mill building so that the same trench could easily serve any addition that might be warranted.

Along with building a modern and efficient mill incorporating these expansion features, much of the planning was devoted to construction of a plant that would be neat, compact and appealing to the eye. Special attention was given to making the plant easy to keep clean and providing for the comfort of the employees so that they would take a personal interest in plant upkeep.

Every effort was made throughout the plant to minimize the amount of physical effort on the part of employees. Push-button control panels were installed. So far as possible the machinery is located on one operating level to minimize stair climbing and facilitate inspection. All inspection is possible without the operator having to be exposed to the weather. We also tried to include as far as practicable the most modern material handling methods, lighting, safety devices and dust control equipment, as well as the most modern electrical equipment which we could obtain.



Main substation is an outdoor type completely packaged by the manufacturer to company specifications.

Expanded metal troughs for electrical wiring are more flexible and more economical than conduit systems.

Indian Creek's Electrical System

The main substation is an outdoor type completely packaged by the manufacturer to our specifications. It includes a three bay steel switching structure which mounts two horn gap group-operated disconnecting switches, 6 hook-operated fused disconnecting switches, and 3 single pole thyrite station type arresters, with provisions for future addition of one horn gap group-operated disconnecting switch and 3 hook-operated fused disconnecting switches. There are two 3,750 kva, 3-phase, 34,500 to 2,400-v oil filled self cooled transformers with the 6 hook-operated fused disconnecting switches connected in the primary circuit ahead of these transformers. Provisions are made for a third transformer which will be required if concentrator capacity is increased to 4,000 tons per day.

Each transformer secondary is throat connected to a lineup of outdoor metal clad drawout type switchgear which includes a transformer secondary air circuit breaker and three feeder breakers. The 2400-v buses of the metal clad switchgear units are solidly tied together by means of an enclosed bus run with provision to tie with the bus of the third unit.

A 10-kva control transformer in the auxiliary section of each unit provides 220-v ac power for compartment heating and breaker closing. A 24-v battery and charger provide a reliable breaker tripping source.

The six main 2400-v feeder circuits serve the following loads:

1. Grinding section rod and ball mills.
2. Two indoor unit substations 2400/480 v.
3. Crushing plant 2300-v motors and 2400/480-v indoor unit substation.
4. Mine hoist and air compressor.
5. Mine underground.
6. Feeder circuit to ventilation and supply shaft located approximately 3,000 ft from main shaft.

The main 2400-v feeder cables to the mill are all rubber insulated 3-conductor with flat metal armor. These feeders are installed in a concrete trench system with branches connecting to the grinding, flotation, crushing, and hoist-compressor control rooms.

All electrical equipment other than the motors, cables to the motors, and the push button stations are located in electrical control rooms at various strategic locations. Blowers equipped with dust filters maintain these rooms at a pressure of about 3 in. water pressure over atmospheric, thus insuring circulation of an adequate amount of dust-free air as well as preventing any dust contaminated air from entering.

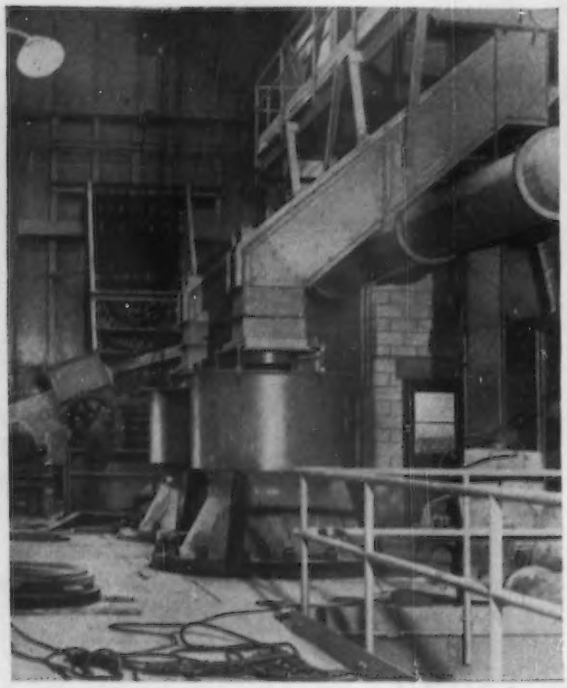
All motors of 150 hp and larger are powered by 2400 v, and smaller motors at 440 v ac.

Push buttons for the 2300-v motors have red indicating lights so connected as to indicate only when the synchronous motors have pulled into synchronism, or the wound rotor motors have the last contactor energized which short circuits the motor rotor circuit.

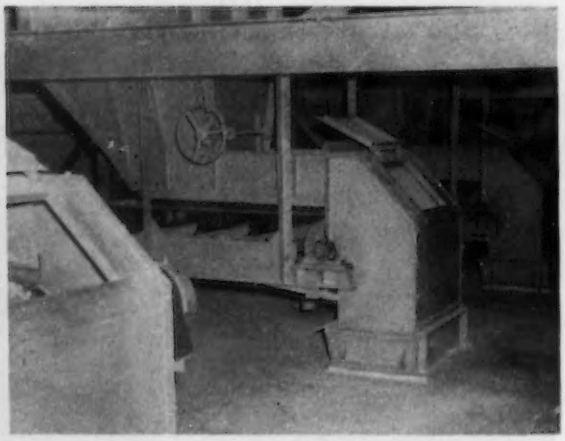
Push buttons for all 440-v motors have red indicating lights to show the starter is energized.

All motor starters for 440-v motors are the combination circuit breaker and magnetic starter type. They are assembled in various groups, each group has its individual circuit breaker in one of the unit substations. Nine identical primary breakers control the 440-v circuits. One in every group of three serves the capacitor so it can be used as a spare. If any interruption occurs, this breaker can replace one of the others and the only loss in operation during the repair would be on the correction of the power factor. The starters are the type which snap onto a vertical bus for ready removal and are equipped with a red indicating light in the door.

Expanded metal troughs on the horizontal carrying wiring have the distinct advantage of being quite flexible. which is a necessity in a modern metal concentrating plant where metallurgists are frequently making changes in circuits and equipment to improve plant efficiency. It is also much more economical than conduit systems installed with high priced labor.



Crushing plant operations are controlled through an interlocking system to insure proper sequence of operation of all crushers and conveyors, and to stop units in proper sequence due to failure of any one. This feature has eliminated all but a small amount of clean-up. Hydraulic adjustment feature of the mantle on the secondary crushers provides easy adjustment of the setting by one man and he can also relieve any choke-up without outside help. Raising and lowering mantle is accomplished by a switch. Auxiliary feeder at extreme left handles ore brought to mill by trucks.

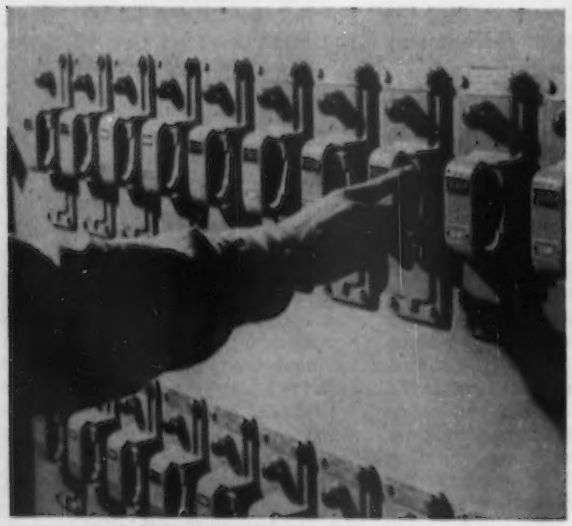


Six belt feeders (three show here) draw ore from the 2200-ton catenary type storage bin. This type of bin gives minimum amount of dead storage, and the six draw points minimize segregation as well as provide more constant feed to rod mill.

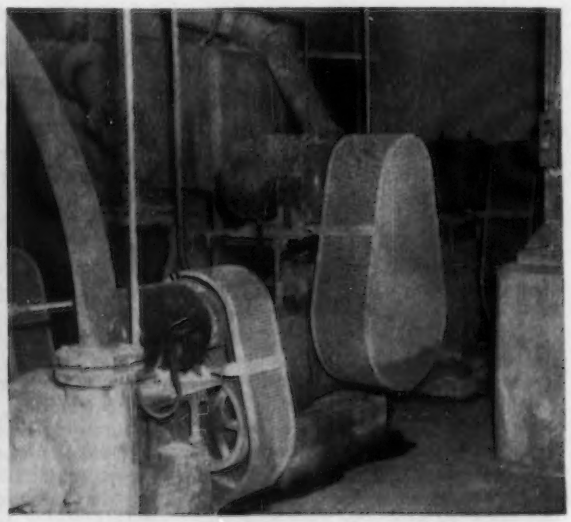
These Design Features

It is the writer's firm belief through observation and experience over the years that the less physical effort an employee has to expend during a shift is repaid in many ways other than minimizing labor costs. A plant layout that provides ease of operation with all phases readily accessible for inspection appeals to the operator's better nature and challenges him to think of various means of further improvement in the operations under his control.

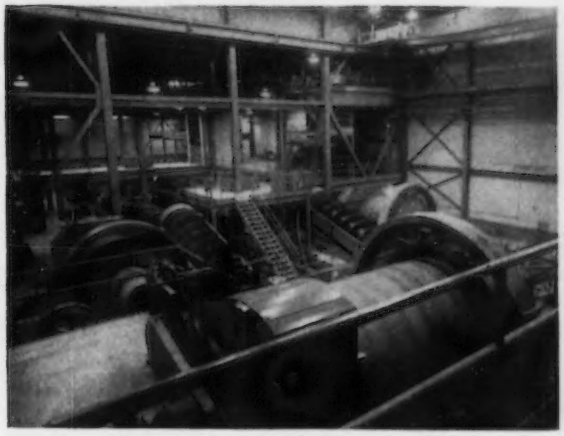
After 18 months of operation at Indian Creek, it has proven practical to operate with one operator per shift in each of the crushing, grinding and flotation sections. In



Centralized push button station is used to start and stop all machinery in the grinding section. All machinery in the flotation section and basement pumps are also started from a push button station located conveniently near the center of the flotation operations.



Basement pumps also have selector switches installed at convenient places like this so that individual units can be operated separately for maintenance purposes. One spare motor is available for each of 7½ hp, 15 hp and 30 hp requirements and is used with variable speed drive.

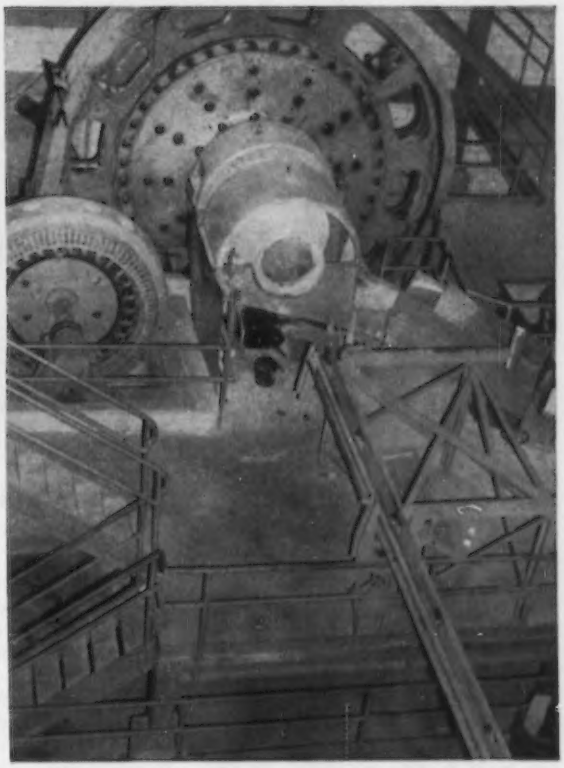


Rod mill, a 9x12-ft unit, is duplicate of five others in use at another of the company's mills in the Lead Belt. Ball mills, 9x8-ft, use same bearings, heads, gears, and pinions as rod mill so that inventory is kept to a minimum.

Are Paying Off

starting, the mill has been brought to full tonnage in less than 15 minutes, and has been shut down completely in less than 30 minutes with little, if any, spillage. The metallurgical results during this period have equaled our expectations.

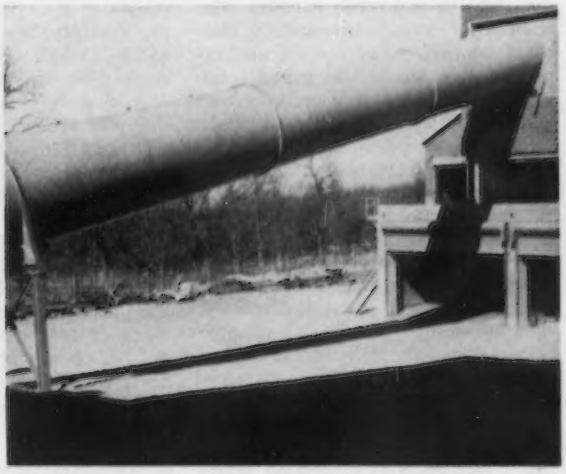
Acknowledgments: The author wishes to acknowledge his indebtedness to the General Engineering Co., Ltd., of Toronto, Canada, who made the detailed design for the plant and furnished detailed supervision during construction, and to Mr. E. H. Tucker, of Newmont Mining Corp., who designed and supervised the electrical installations.



Rod charger has proved a great time saver. Rods are placed on the rack by an overhead crane and rolled into position where they can be easily loaded into the rod mill. Balls are stored in a bin from which they are fed through a loading chute into a bottom dump bucket. An overhead crane discharges the bucket load of balls into the mills.

High lighting specifications are maintained by mercury incandescent lamps which can be installed above bridge cranes. Eliminating windows eliminates dirty or broken glass, insures consistent light for judging metallurgical results like color and texture of froth.

LIGHTING SPECIFICATIONS	Foot Candle Power
Control rooms	8–12
Conveyor ways	8–12
Under floors, stairways, etc.	6–10
Outside lighting	3–5
Main crushing plant	20–25
Grinding and flotation	20–25



Tubular conveyor is also windowless. This construction offers less wind resistance, is stronger structurally than ordinary framed sheet iron conveyor housing normally used in the district. For safety of personnel, cords connected to normally closed contact switches in control circuits are installed along all conveyor ways. In an emergency, equipment in any section and that following it, can be stopped by a light pull on the cord.

Is Mining Making Full Use of Modern

With the growing emphasis on the electrical aspects of the mining industry, here are some valuable hints for the mining engineer as well as for the electrical engineer who may be entering the mining field.

E. H. TUCKER
Newmont Mining Corp.

GENERALLY SPEAKING, in the last few years operators of nonferrous metal mines have begun to realize that good electrical and mechanical engineering are an important adjunct to mining engineering for successful mine operation.

Electrical engineers have not been greatly attracted to the mining industry. There have been very few instances where the industry has set up training programs for mine electricians or mechanics, and yet electrical use in mine and mill is entirely different than that in any other industry. The amount of money invested in electrical equipment warrants more expenditure in the obtaining and training of the talent for installing and maintaining it.

There is no doubt that mechanical and electrical engineers, trained in mining to appreciate the peculiar problems involved, could help improve efficiency.

Mining would probably do well to investigate methods and means used in other industries to improve efficiency.

Where to Begin

In applying good electrical and mechanical engineering for the design and construction of new mine plants there is no set method; each plant must be a tailor made job. Certain general principles of good engineering always apply.

Development of a mine and plant, of course, starts with the orebody and by one method or another the miner proves the orebody as to grade and size. From this he can work out his economics on size of plant, type of mining, and can generally give, or should be able to give, the metallurgist enough ore or other necessary information for him to lay out his flowsheet to handle efficiently the tonnage and grade of ore in the concentrator or mill.

At this stage it would be well that both electrical and mechanical men work with the miner and metallurgist so that a careful study be made to determine horsepower requirements, type of mining to be employed, compressors, hoists, haulage systems, pumping, etc. With the metallurgist, the flowsheet should be studied and again careful evaluation made of equipment, drives, and horsepower requirements.

From this the electrical engineer will have the information for a preliminary general design layout of his main sub-station (or power plant), type of system, distribution voltage and feeder circuits. If he is realistic about it and has had previous experience he knows that both the miner and metallurgist are certain to come along at some later date and add a few horsepower here and there. (They never cut them down, and some times these little odd amounts add up to quite a bit.)

It costs relatively little at this point to be liberal with feeder sizes and transformer capacity. Quite often at this stage, because of time element and estimated trend of base metal prices, major items of equipment must be ordered long before any detail has even been started. Thus, this part of the system must be flexible, with a small margin of extra capacity. Some thought should be given to what could be done at a later date if some one says "let's increase the capacity." Also, in laying out the main sub-station or power plant it is possible to plan so for additional power generating equipment or, in the case of the main sub-station, additional transformer capacity.

In most instances the ring system of distribution, with the relaying and switching necessary to obtain the benefits of continuous service, is not economically advisable, the branch feeder or radial type of system being adequate and probably better adapted to mine and mill. Other industries are not affected with these problems which are peculiarly inherent to the mining plant and many approaches to these problems in mining would probably not be considered good practice economically or otherwise in other industry.

The policy of the electrical designer should be to minimize labor requirements, utilize the latest type of equipment, with as simple a system as good practice permits, with special emphasis on design to obtain efficient operation and maintenance.

Package Units

In the selection of electrical equipment, full advantage should be taken of electrical manufacturers' "complete manufactured units." This type of equipment has a higher first cost, and its use will effect plant design both electrically and mechanically if full value is to be derived from its use. However, its incorporation in a plant

Electrical Equipment and Engineering?

lowers installation cost, not to mention its better appearance, as manufacturers can do a better job at much less cost than can be done in the field at present labor costs.

A packaged unit sub-station of this type can be built to the specifications best suited to the mining plant. It is simple and cheap to include, if deemed necessary, provisions for adding parallel banks of transformers, or additional distribution breakers. Careful study should be made of existing power source or problematical future increase in power source in order to have ample interrupting capacity for protective and switching devices.

Underground Applications

Cable feeders of the proper voltage and size for underground service are now manufactured with new materials and construction so they are much lighter and easier to install and handle. In vertical shafts they can be suspended from the surface in 1,000-ft lengths or more, depending on size. Distribution to various parts of the mine depends on the system of mining. Pump stations, underground crushing plants, dc trolley generating stations and the like are permanent and electrical installations can be made such. Rooms for transformers (which should be askarel cooled), switchgear and starters can be located conveniently and constructed so they are dry. This can be accomplished quite often with gunite or a fan type heater to keep equipment dry and sweating to a minimum.

For other mining loads, such as slusher, ac-operated mobile jumbos, loaders, dc shuttle cars, a flexible system of power feeders, mobile transformer stations and mobile rectifier units can be used. Manufacturers are most co-operative in making these units to fit varying conditions of mobility and construction.

The ac feeder circuits can in most mines be safely suspended on carrier cables fastened well up and to one side of drifts, and can be protected at chutes or open sections of stopes by sections of pipe split in half and fastened over the cable.

Mobile ac transformer stations should preferably be askarel filled transformers with wye-connected secondary. If these units serve mobile rubber tired units, such as drill jumbos or loaders, then circuit breakers with ground current trips set for 5 to 10 amp should be a part of the unit substation. With current limiting resistors connected from the transformer neutral through a separate conductor included in the cable for this service and connected to the motor frame and control on the mobile unit, operators will be safer from injury due to electrical shock than if they depended entirely on a ground chain (or something similar) and a ground wire in the portable cable feeder.

Dc shuttle cars, if used, can be connected to existing dc circuits by a 500- to 600-ft cable reel; they can be equipped with local two wire trolley system supplied from mobile transformer station and rectifier with a two conductor slipper connected to the end of the cable reel, or they may be equipped with a diesel driven MG set. In the case of the latter, good ventilation and exhaust conditioners and scrubbers are definitely required.

This same condition applies to diesel underground track haulage. Diesel locomotives underground are safe if certain precautions are taken. They should be used only where there is an adequate circulation of fresh air, should have good scrubbers, properly maintained, and oversize engines so that there is no chance they will lug and hence smoke. They should be worked over in the shop more frequently than for a similar motor or truck duty in the open air. If a few of these precautions are observed and management is conscientious about their use they will find an important place in underground haulage. If not, unions are liable to ban their use underground, and there are many places where they are far superior to either battery or trolley haulage.

Surface Installations

Surface loads at a mining plant would probably include hoist, compressors, crushing plant and concentrator.

For the surface plant all electrical equipment, other than cables to the motors and the push button stations, should be located in electrical control rooms at various strategic locations. Blowers equipped with dust filters should maintain about 3 in. of water pressure over atmospheric in these rooms, thus ensuring circulation of an adequate amount of dust-free air and preventing dust-contaminated air from entering.

Quite often hoist and compressor installations are adjacent to each other and the electrical equipment for these units can be packaged units in a metal clad equipment line-up.

Compressors should have 0.8 leading synchronous motors, full voltage starting. Since it takes just so much energy to start a unit and the best you can do is lengthen the time interval a few seconds at a slightly reduced rate with some of the more expensive cumbersome starters, such as reduced voltage reactors and/or two winding motors.

Hoists can have the conventional wound rotor motor and control or, if they are over 600 to 800 hp then consideration should be given dc types.

In the crushing plant, the motor driving the primary crusher should be wound rotor, as this type motor has characteristics better suited to the shock loading of the crusher. The starter should be fully magnetic. The motor should be totally enclosed or should have a ventilating system and housing incorporated as an integral part.

If power factor correction demands

it, then motors on secondary crushers can be synchronous, dust-protected with full voltage starters. I have seldom seen a stuck secondary cone crusher that could be broken loose with the wound rotor motor that was connected to it; they generally have to be cleaned out. So why put wound rotors on them if you want synchronous? There are, however, secondary crushers that, by use of a hydraulic system, can quickly clean a stoppage.

Electrical control for the crusher motors should be located in the crusher electrical control room adjacent to the crushing plant and consisting of a line-up of metal enclosed equipment.

Also located in the crushing plant electrical control room should be the load center unit sub-station to transform to lower voltage for the smaller motors used in the plant. These units should not be over 750 to 1,000 kva, depending on the system characteristics, so that interrupting capacity rating on the secondary side is low enough to fit the rating of small motor circuit breakers and starters.

If these units do not have individual primary breakers, they may be equipped with current limiting fuses and/or air interrupter switches. They should also be equipped with low voltage air circuit breakers for the respective motor control centers each supplies. The transformers should be wye secondary with solid grounded neutral.

Grinding Mill Motors

Ball mill and rod motors can be synchronous and should be designed to take a leading current to help correct for the lagging component taken by induction motors. The starters should be a line-up of metal clad units in one of the mill electrical control rooms. Full voltage starters can probably be used, and motor starting kva inrush can be limited by motor design to a value acceptable to most power systems. Application experience indicates that full voltage torques for rod and ball mills should not be less than 180% for starting torque, 120% for pull-in torque, and 225% for pull-out torque. For competitive reasons, motors for this service are sometimes quoted and offered with torques lower than these. Such motors may give starting trouble under loaded conditions. (See *E&MJ*, July 1954.)

Small motor load consisting of flotation, pumps, feeders, conveyors, filtering equipment, etc., should be served from load center unit sub-stations located near the centers of load in enclosed pressurized rooms. The number of these units depends on the size of the concentrator. These units should be similar in size and specification to those in crushing plant.

Push Buttons

Push buttons for the larger high voltage motor starters should have red indicating lights to indicate only when the synchronous motors have pulled into synchronism, or when the wound rotor motors have the last contactor energized, which short circuits the motor rotor circuit. Push buttons for all 440-v motors should have red indicating lights to show the starter is energized.

Push buttons for all units of the crushing plant are located on one panel on an operator's platform. An interlock system is imperative to ensure proper sequence for operating all conveyors and crushing equipment, or to stop the proper units in a sequence due to failure of any one. Selector switches should be installed on the starters to allow individual units to be operated for maintenance purposes. For the safety of personnel, cords connected to normally closed contact switches in the control circuits should be installed in convenient locations along all conveyor ways, so that in an emergency equipment in that section and in the sequence following it can be stopped by a light pull on the cord.

In the concentrator, each of the sections (grinding, flotation, and filtering) should have panels with the push button stations for their respective section. At this location an indicating wattmeter for each rod and ball mill will greatly assist the operator.

All motor starters for 440-v motors should be the combination circuit breaker and magnetic starter type. These are assembled in various groups, each group having its individual circuit breaker in one of the unit substations. The starters are the type which snap onto a vertical bus, and are equipped with a red indicating light in the door. Each group of starters serves a particular section and can vary from 150 to 450 hp connected to each.

All wiring to the 440-v motors should be rubber insulated neoprene multi-conductor cable of the fireproof type. These cables may be laid in trenches in the floors of the electrical control room from the starter groups, and in an expanded metal trough system from the control rooms throughout the plant. Short runs of pipe or conduit protect the cables in the runs from the expanded metal trough to the individual motors.

This type of wiring has the distinct advantage of being quite flexible, which is a necessity in a modern metal concentrating plant where metallurgists are frequently making changes in circuits and equipment to constantly improve plant efficiency. It is also much more economical when compared with conduit systems installed with high priced labor. In particular, where plants are not completely designed with full detail before construction starts, this type of wiring will allow the flexibility necessary and will give a greater degree of independence from the work progressing in other parts of the plant construction.

Instrumentation

Instruments in chemical plants for control and indication are generally quite abundant and represent a large part of the equipment cost. The concentrator or mill at a mine plant generally goes to the other extreme. This is probably because experience with instruments of this type has not been too satisfactory and is probably due to lack of experience in installing and maintaining. I believe that a reasonable amount of instrumentation can be used to advantage in a concentrator, not to "gold plate" a job but to increase efficiency by improving operation and lowering costs. If they can be made to do this they are justified and proper steps should be taken to maintain them.

There are many types of tools and devices being designed and invented today, some application of which might fit in to modernize mining plants. A few of these are:

Wired television between hoist men and various mine levels or loading stations or in mill for operator's convenience to observe remotely located units of equipment.

Automatic phone exchanges with the multiple uses they have for signaling and conference service.

Radio for train dispatching and general communication.

Self synchronous motor devices which can be adapted to a multitude of control problems.

Strain gauge units for weighing and weight control.

Electrical equipment and engineering is assuming a more and more important role as a cost cutting tool for the mining industry. It is hoped that the above points may be of some use in appraising your own present or future electrical installations.

How to Keep Solids Flowing In Bins and Hoppers

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THE PROBLEM OF FLOW of bulk solids is of major importance in the design and operation of bulk handling storage plant and processing equipment. The purpose of a storage plant is to receive material from its sources, hold it in readiness, and feed it at the required time and rate for further processing. The operation of a processing plant depends on the steady supply of material. When this is interrupted through failure of material to flow, the whole operation may break down. When the live storage capacity falls below the designed value, it can play hob with the most carefully laid out schedule of operation.

During the past few years, the writer has been working on the development of the principles of flow of bulk solids with the final aim of placing design for flow on a quantitative basis. The results have been reported to engineering societies[1, 2] and in a number of publications[3, 4, 5, 6, 7]. Based on observations of flow in industrial systems and on tests made on model bins, the writer has developed a theory to explain the mechanics of flow. This can be summarized as follows: a loose bulk solid has no strength, it slips through one's fingers. In a bin, under pressure, a solid compacts and builds up strength. When the gate is opened or the feeder started, conditions of support of the mass are changed with resulting redistribution of pressures. If the new pressures are higher than the strength of the solid, the solid flows; otherwise, an obstruction develops.

In development of the theory of flow, the writer has used methods of soil mechanics, and structural and stress analysis. The arching or hanging up of a bulk solid in a bin or chute poses problems of stress and stability similar to those encountered in the design of an arch or dome structure.

Flow formula

One of the obstructions to flow is doming of material across a section of a bin or spout. The writer has made an analysis of the stress conditions within a doming bulk solid[4] and obtained the following formula for the instability of the dome which has to be satisfied in order that material flows $B > b_h\, b_v\, (f_c/w)$. B is the width of the cross-section, b_h and b_v are shape coefficients dependent, respectively, on the horizontal and vertical cross-sections of the bin or spout. The value of b_h lies between one, for an infinitely long slot cross-section, and two for a circular cross-section; b_v is always less than one; f_c is the peak unconfined compressive strength of the material. This expression is taken from soil mechanics: theoretically, at least, it could be measured in the same way as the compressive strength of concrete—by compressing a test cylinder to failure. In actual fact, this direct method is not applicable, because a cylinder made of a bulk solid would likely disintegrate under its own weight, and certainly its weight would affect the test values to an excessive degree. w is the unit weight of the material. We see that ratio f_c/w is of a linear dimension, and it is measured in feet, the same as width B. From the formula it is evident that the lower the ratio f_c/w, the better the flow of material.

FIG. 1 Flow-factor testing unit.

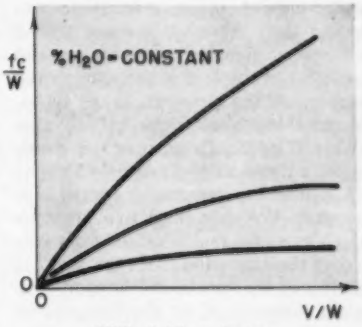

FIG. 2 Flow factor.

The flow-factor

Ratio f_c/w is a property of the bulk solid. This ratio governs the behavior of the solid in a bin or spout. It, therefore, warrants further attention. What factors affect this ratio? Considering a sample of a given material, with all other factors constant, the degree of compaction which material undergoes is the most important determinant of strength f_c. A loose material has hardly any strength at all, but as pressure is applied, material compacts and gains strength. Compaction affects unit weight too, but to a lesser degree. Compaction is measured by the highest pressure v within material. It is convenient to express this pressure as head of material v/w, measured in feet. The function $f_c w = F(v/w)$ is called the flow-factor of a bulk solid.

In order to measure the flow-factor, the writer has developed special apparatus which is shown in Fig. 1. This is a transverse shear testing machine.

Typical flow-factor functions are shown in Fig. 2. In view of the fact that high strength f_c and high ratios of f_c/w are conducive to doming, the lowest curve represents the material of highest flowability. It is also seen that as pressure head v/w increases, so does ratio f_c/w. This leads to an important principle in design for flow: **Pressures within material should be kept low.**

For a given bulk solid within a given range of compacting pressure, the next factor which most affects flowability is the moisture content of the solid. To demonstrate this influence, values of ratio f_c/w are plotted in Fig. 3 as a function of $\%H_2O$, for a constant compacting head v/w. We see that ratio f_c/w increases rapidly with the

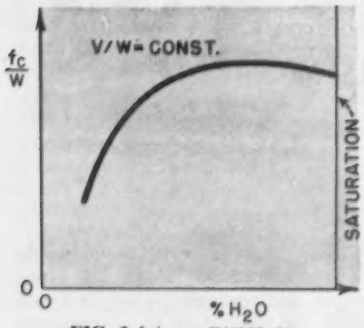

FIG. 3 $f_c/w = F(\%H_2O)$.

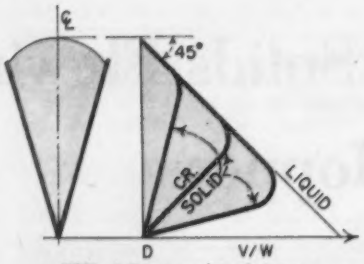

FIG. 4 Pressure in a hopper.

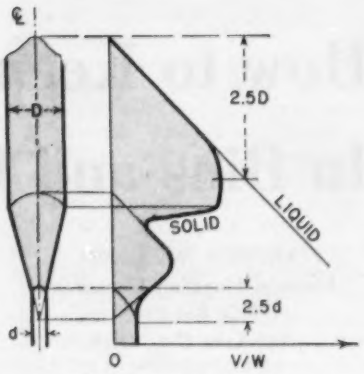

FIG. 5 Pressure in a bin.

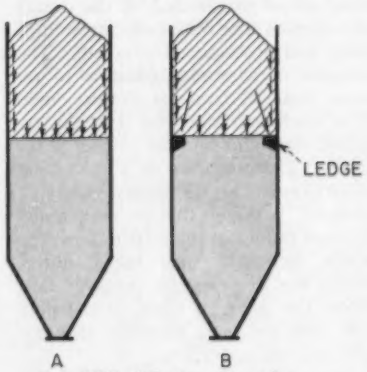

FIG. 6 Ledges in a bin.

addition of water, reaches a maximum and then falls off somewhat toward saturation point. Tests made to date do not yet justify a statement that this is typical behavior, although this behavior has been encountered in a number of cases.

Pressure within a bulk solid

It is interesting to compare the properties of a liquid with those of a solid, under static conditions.

To illustrate the effect of these properties on pressure within a hopper, diagrams of pressure head v/w are shown in Fig. 4. Pressure in the liquid increases linearly with depth. For the bulk solid, the vertical pressure head along the centerline of the hopper is shown. We see that from the top of the mass this pressure at first follows the liquid line, then falls below liquid pressure and drops to zero at the apex of the hopper.

This radical difference is due to the fact that, whereas the weight of the liquid is transferred to the walls through pressure alone, the weight of the solid is transferred through both, pressure and shear. Thus, the hopper walls provide better support to the solid than to the liquid, hence the build up of pressure in the solid is less.

Another example of pressure head distribution is shown in Fig. 5 for a bin narrowing down to a vertical spout. Pressure in the solid is again shown as it acts in the vertical direction along the centerline of the bin. In the vertical portion of the bin, solid pressure head v/w first increases linearly, following the liquid line, then levels off, so that it remains practically constant below a depth of about 2.5 diameters of the bin. At the transition to the hopper, pressure drops abruptly and then increases linearly within the hopper, reaches a maximum and declines toward zero at the apex of the hopper. At the transition to the spout, pressure levels off again at a value governed by the diameter of the spout. Below a depth of spout equal to about 2.5 diameters, pressure is practically constant. We thus have two areas in which pressure reaches maximum values: at the transition from the vertical portion of the bin to the hopper, and in the lower half of the hopper. In these areas material develops the greatest strength and has the greatest tendency to dome and obstruct flow.

Note that pressure in the lower part of the hopper is practically independent of the material in the vertical portion of the bin.

What can be done to keep pressures within material low? Consider the shaded mass of material confined in a bin, Fig. 6A. The weight of that mass is partly transferred to the walls through shear; the balance of the weight exerts a pressure on the material below. If the support at the walls could be increased, the pressure on the material below would be reduced correspondingly. There are several ways in which this can be accomplished:

1) By providing ledges at the bin walls, as shown in Fig. 6B. The ledges restrict the subsidence of the mass at the circumference, producing differential settlement and the development of a pronounced doming effect within the material. As a result, the ledges take on a substantial share of the total weight of the shaded mass, thus relieving pressure on the material below.

2) By providing a shelf inside the bin. This works, essentially, like the ledges.

3) By providing vertical partitions in the bin. The partitions provide additional support to the mass of material, they reduce the effective diameter of the bin. It has been known for a long

Properties of Liquid vs Bulk Solid

Pressure at a point	**Same in all directions**	**Varies with direction.**
Pressure variation	**Increases linearly with depth**	**In unconfined masses increases approx. linearly with depth. In masses confined in bins etc. depends on the shape and size of the receptacle.**
Shearing stress	**None**	**None, in principal planes of pressure. In other planes, stress varies; with a maximum limited by the coefficient of internal friction, which is fairly constant for a given solid, cohesion, which depends on the degree of compaction, and the minor pressure that acts at the considered point.**

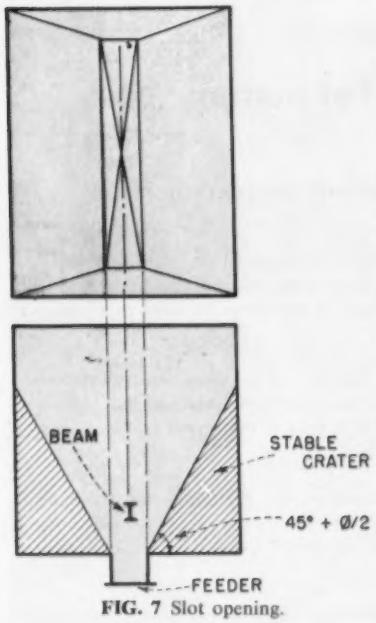

FIG. 7 Slot opening.

time that pressures are roughly proportional to the diameter of a bin. These devices have been described by the writer in previous publications.

So far, pressures have been considered under static conditions. Significant pressures can also be induced by outside vibrations, by material dropping into the bin from a considerable height, and by uneven flow of material within the bin. Vibrations are particularly harmful to flow in spouts and in steep hoppers. Uneven flow occurs when there is a tendency for material to dome in the areas of high pressure shown in Fig. 5. A temporary cavity can form under the dome, and when the dome collapses, a large mass of material drops down and, depending on the conditions, either compacts heavily and obstructs flow, or aerates and floods the feeder.

Live capacity

Not infrequently it is found that the actual live capacity of a bin or storage pile does not measure up to the expected design capacity. It is found that the slope of the crater which material forms around the opening or openings is a great deal steeper than had been expected.

The writer made an analysis of the stability of crater walls[4] and concluded that a slope angle close to 45 deg $+ \phi/2$ should be considered stable for a crater, Fig. 7. ϕ is the angle of internal friction of the material which is usually larger than the angle of respose. Assuming values for ϕ between 30 deg and 50 deg, we obtain for the stable crater a slope angle of 60 deg to 70 deg. Experience seems to bear this out. This angle is a great deal steeper than the angle of repose or the 45 deg angle, which are often used for an estimate of storage capacity during the design stage of a project.

The actual crater angle is difficult to predict. It varies with moisture or clay content of the material and, in extreme cases, the angle can be 90 deg with resulting funneling or piping over the opening and live capacity reduced to zero. It is sometimes found that it takes several weeks[8] for the crater to build an objectionable slope, and that periodical cleaning of the crater maintains a reasonable live capacity of the bin or pile. Another way to prevent the build up of a steep crater is to provide a shelf at a suitable height in the path of the falling material, Fig. 8b. Material bounces off the shelf, hits the walls of the crater and disturbs them sufficiently to check the build up.

Both analysis and experience point to the conclusion that bins and storage piles with slot openings, Fig. 7, are by far the best in preventing trouble with crater build up. Slot openings have two drawbacks: the feeder area is large, even though the feeder can be made comparatively narrow, with the result that the feeder tends to be expensive, and the hopper, or in the case of flat bottom bins, the floor of the bin, presents more of a structural problem. However, these drawbacks are more than compensated by operational advantages, which also include greater freedom from arching across the opening and less segregation. When handling material of large particle size, or when pressure of material on the belt seems excessive, it may be advisable to place a beam above the feeder, Fig. 7.

Hopper design

As material flows down a hopper, the cross-section of the hopper decreases and, in order that doming does not occur, the strength of the material must also decrease. This will take place providing the compacting pressure also decreases at a sufficient rate. Thus, in the pressure diagram of Fig. 4, there exists a critical pressure curve cr. If material develops pressures below critical, the resulting compaction is insufficient to build up strength for a stable dome, material can flow down to an opening limited only by the particle size. On the other hand, if material develops pressures above critical, doming develops below a certain cross-section of the hopper.

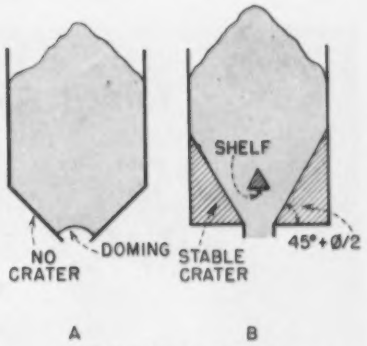

FIG. 8 Crater build-up.

For a given material, the shape of the pressure curve is governed by the degree of support that is afforded the flowing material by the hopper. The better the support, the lower are the pressures, and the better the flow.

If the hopper is to give good support to the flowing material, it is necessary that:

(1) The hopper be able to transfer the shearing stresses which act between the material and the walls. Analysis[4] shows that shearing stresses reach a maximum within a cone inclined at about 45 deg $+ \phi/2$ to the horizontal, Fig. 8b. When the slope of the hopper is close to this value and the frictional and adhesive properties of the joint between material and wall are inferior to the internal frictional and cohesive properties of the material, the joint provides a weak plane. Bodily slip of the flowing mass may occur along this plane with a resulting increase in the pressures. In addition, the slippage may produce wedging of the material within the hopper leading to high lateral pressures.

When the roughness of the walls is of the same range as the particle size of the material, the walls provide good shearing support, but when the particles are comparatively large, slippage is unavoidable. In the latter case the joint between material and wall must either be strengthened by the addition of ledges, or the walls must be removed from the proximity of high shearing stresses by reducing the slope of the hopper. Material will then build its own natural hopper.

(2) The hopper provides firm resistance to the pressure from the flowing material. The hopper walls must subside decidedly less than the flowing material. When the handled material forms its own crater, the stable material of the crater should not be disturbed by barring or air jets, it

(*Continued on p 93*)

Table I. A quick guide to the world of pumps

CLASS	TYPE		IMPORTANT GENERAL FACTS
CENTRIFUGAL	Volute		The majority of centrifugal pumps built in the U.S. today are volute type. They are available as horizontal or vertical pumps, single- or multistage for wide flow ranges
	Diffuser		Diffuser-type centrifugals find many uses as multistage high-pressure units. Originally more efficient than volute-type pumps, today efficiency of both types is about equal
	Mixed-flow		Mixed-flow centrifugal pumps are ideal for low-head large-capacity applications. Usually vertical, they have a single-inlet impeller. Some horizontal units are built
	Axial-flow		Axial-flow units, often called propeller pumps, develop most of their head by lifting action of vanes, are usually vertical, and best suited for low heads, large capacities
	Turbine or regenerative		For clear liquids, turbine pumps, either horizontal or vertical, fill a need between other centrifugal and usual rotary designs. They are low- to medium-capacity, high-head
ROTARY	Gear Vane		Gear pumps consist of two or more gears (spur, single- or double-helical teeth), while vane pumps have a series of vanes, blades or buckets turned by a single rotor. This rotary class also includes lobe or shuttle-block designs
	Cam-and-piston Screw		Cam-and-piston rotaries, like most types in this class, are positive-displacement units, giving steady discharge flow. Along with screw-type pumps, and related designs, they handle a wide range of nonabrasive viscous liquids
RECIPROCATING	Direct-acting		Old standbys for years, direct-acting steam pumps now are available in many designs for handling cold or hot water, oil, and a wide range of industrial liquids of many types
	Power		Power pumps are driven from outside through a crankshaft or other device. Capacities range from very low to medium flows, at pressures up to 15,000 psi, or higher
	Crank-flywheel		Crank-and-flywheel pumps are one form of reciprocating power pump, so designated to distinguish them from power pumps using, for example, an eccentric as drive mechanism

What to Expect of Modern Pumps

An analysis of type, design, installation, materials of construction and performance of modern pumps for mines and metallurgical plants.

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Vice-President,
Allen-Sherman-Hoff Pump Co.
Philadelphia, Pa.

The drawings, the large tables, and a part of the text of this article have been taken from the special handbook section on pumps, published as a part of the October 1954, issue of Power, *a McGraw-Hill Publication.*

PUMPS, OF ALL TYPES, are today doing jobs in the mining and metallurgical field never tackled before and only recently thought of as being at all possible. This advance results not from any basic design development, but from the advances made in materials and techniques used in production of the pumps along with an increase in knowledge of application.

This section is not intended to be a review of pump design or principles. A most comprehensive book on this subject is "Pumps" by Kristal & Annett—(McGraw-Hill 1940). There also have been numerous articles in various publications over the past ten years, climaxed by *Power* magazine's October 1954, issue with "Pumps."

What we are going to try to do herein is to augment all of this work and much published elsewhere by setting forth some of the basic practical considerations in the selection of pumps to be used in the mining and metallurgical field.

In general, there are three types of pumps. These can be stated as: reciprocating pumps, rotary pumps (both of which are positive displacement pumps), and centrifugal pumps in which the water passage is never closed. There are a number of ingenious variations of these types.

Each of these classifications may be further broken down into a number of different types as shown in Table I, and in the drawings on p. 88.

A recent survey indicates industry as a whole uses 66% centrifugal, 22% reciprocating and rotary about 12%. Included in the centrifugal classes are all the deep well pumps which are of the turbine type.

For surface plant use, deep well water pumps play an all important

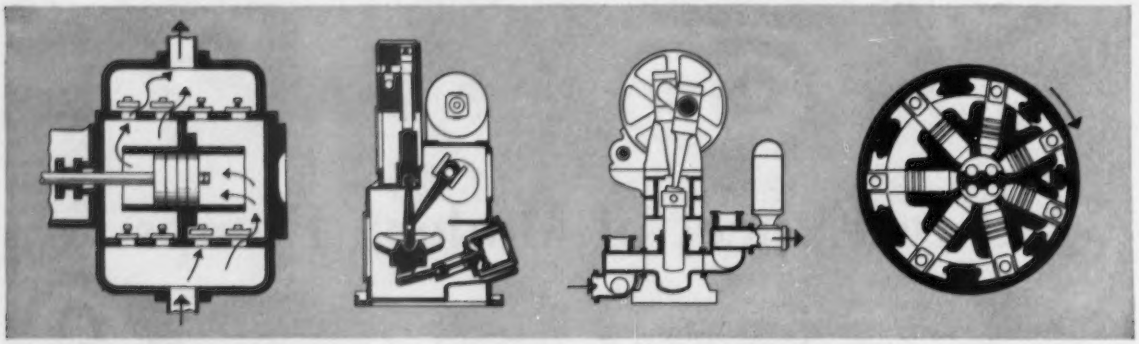
Table II. Materials for Pumping Various Liquids

Liquid	Condition	Material selection
Acid, acetic	Conc cold	8, 9, 10, 11, 12
Acid, hydrochloric	Commi conc	11, 12
Acid, nitric	Conc boiling	6, 7, 10, 12
Acid, sulfuric	>77%, cold	C, 10, 11, 12
Alcohols		A, 8
Asphalt	Hot	C, 5
Beer		A, 8
Beet juice		A, 8
Brine, CaCl	pH>8	C
Brine, CaCl	pH<8	A, 10, 11, 13, 14
Brine, NaCl	<3%, cold	A, 6, 13
Brine, NaCl	>3%, cold	A, 8, 9, 10, 11, 13, 14
Calcium hypochlorite		C, 10, 11, 12
Carbon tet	Anhydrous	B, C
Formaldehyde		A, 8, 9, 10, 11
Gasoline		B, C
Glue	Hot	B, C
Lead	Molten	C, 3
Milk		8
Molasses		A, 8
Mustard		A, 8, 9, 10, 11, 12
Oil, crude	Hot	3
Oil, fuel		B, C
Oil, kerosene		B, C
Oil, lube		B, C
Sewage		A, 8, C
Soda ash	Hot	8, 9, 10, 11
Sodium hydroxide	Aqueous sol	C, 5, 8, 9, 10, 11, 13, 14
Sugar	Aqueous sol	A, 8, 9, 10, 11, 13
Tar	Hot	C, 3
Water, feed	Not evaporated	
	pH <8.5	C
	pH >8.5	B
	Evaporated, any pH	4, 5, 8, 14

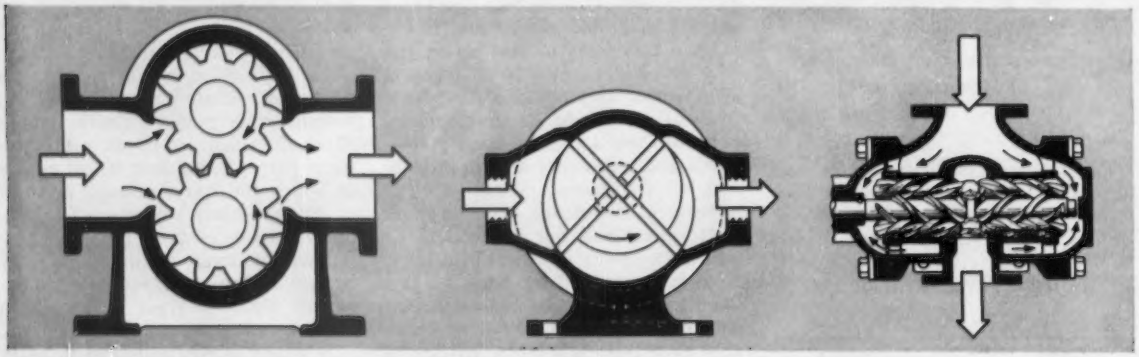
Table III. Hydraulic Institute Materials Selections and Designations

Institute selection no.	Corresponding national society standards designation ASTM	ACI	AISI	Remarks
1	A 48, Grades 20, 25, 30, 35, 40, & 50	.....	.....	Gray iron — six grades
2	B 143, 1 B & 2A; B 144, 3A; B 145, 4A	.....	.....	Tin bronze — six grades (includes two grades covered in detail in *Standards of Hydraulic Institute*)
3	A 216, WCB	.....	1030	Carbon steel
4	A 217, C5	.....	501	5% Chromium steel
5	A 296, CA15	CA15	410	13% Chromium steel
6	A 296, CB30	CB30	...	20% Chromium steel
7	A 296, CC50	CC50	446	28% Chromium steel
8	A 296, CF8	CF8	304	18-8 Austenitic steel
9	A 296, CF8M	CF8M	316	18-8 Molybdenum austenitic steel
10	.....	Cn-7MCu	...	A series of highly-alloyed steels normally used where the corrosive conditions are severe
11	.....	.....	...	A series of nickel-base alloys
12	.....	.....	...	High-silicon cast iron
13	.....	.....	...	Austenitic cast iron
14	.....	.....	...	Monel metal
15	.....	.....	...	Nickel

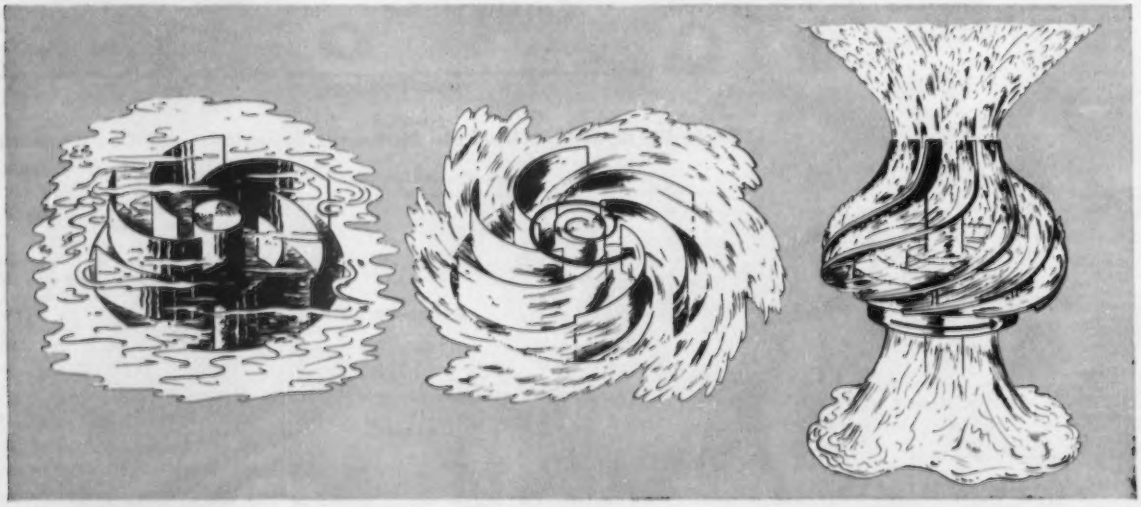
NOTE: ASTM — American Society for Testing Materials; ACI — Alloy Casting Institute; AISI — American Iron and Steel Institute



RECIPROCATING For metering, proportioning, and high pressure service, this type finds new uses. Direct-acting steam pumps (left) discharge liquid on each stroke. Power pumps (center two) have various valve and plunger arrangements, but are usually single-action, drawing in liquid on one stroke, pumping it out on the next. Radial-piston pumps (right), attach pistons to outer ring with variable center of rotation to create suction.



ROTARY These pumps resemble reciprocating in being positive-displacement units, but have steadier flow. Action of rotary-gear pump (left) is obvious. Sliding-vane rotaries (center) come in several designs. This shows vanes sliding in and out of rotor, held against casing by centrifugal force, trapping liquid between them. Third is screw type pump, in which liquid moves in pockets formed by threads. Clearance is important factor in many rotary designs.



CENTRIFUGAL These diagrams show action of centrifugal pumps. At left is an impeller of centrifugal pump at rest. In center, it is rotating to indicate how liquid is thrown outwards by centrifugal force acting along blades. As liquid flows out, suction develops at center, and if more liquid is available there (i.e., from suction pipe) steady flow results. At right is shown how deepwell pumps direct flow upwards.

part in supplying the plant with necessary process water.

Centrifugals are used for the most part in metallurgical plants since they are the class of pump best suited to materials handling which constitutes the bulk of process plant work.

Materials for Pumps

Eight important factors affecting choice of materials for pumps are: suspended-solids abrasiveness, corrosion resistance, electrochemical action, liquid temperature, head per stage, discharge pressure, structural considerations, pump load-factor.

Tables II and III summarize the broad experience of pump makers and users with various materials and liquids. Materials listed are applicable to all classes of pumps as far as corrosion-resistance characteristics are concerned. But in some pumps, design considerations impose differing physical requirements.

Obviously a tabulation cannot recognize all possible construction variations but must concern itself primarily with the general problem of corrosion. This must be remembered when evaluating merits of the various materials.

Materials listed are those commonly used in the principal parts of the pump, such as casing, impeller, cylinders, etc. Trim items like sleeves, glands, rings, valves, etc. may differ to meet some mechanical requirement, but the material selected should be suitable for environment.

Because of the many variables, no one can say with certainty that some one material will best withstand corrosive attack of a given liquid. So more than one type is usually listed in Table II. Order does not indicate relative superiority—factors predominant in one installation may be almost nonexistent in another.

Symbols used in Table II are A, an all-bronze pump, B for bronze-fitted pumps, and C for all-iron pumps. Other materials, including a large number of special corrosion-resistant types, are listed in Table III.

In Standards of Hydraulic Institute, par E-19, Data Section, a helpful form to aid the pump manufacturer select the best materials for a given liquid is presented. It is extremely useful to all prospective pump purchasers.

Bronze finds much use in centrifugal pumps because it doesn't rust, is easier to machine than iron, can be given a smoother finish and theoretically permits higher efficiencies. But its limitations may prevent its use.

Casings are cast iron in bronze-fitted and all-iron pumps. For corrosive, high-temperature and high-pressure jobs, other materials find use. Bronze casings are popular for mildly corrosive liquids, cast or forged steel for higher pressures and temperatures.

Materials Handling Pumps

In the field of materials handling pumps, the materials of construction and the means of keeping the pumped solids out of a stuffing box are the two points stressed.

In pumping clear liquids, it is usually only a problem of providing the best corrosion-resistant materials and equipping the pump with a mechanical seal.

Such is not the case in pumping materials, because abrasion can be combined with corrosion to upset all previous experience. Mechanical seals have not as yet been produced which will stand up under materials handling service where any appreciable amount of solids is being handled.

The end result is an entirely different approach to the problem. Water seals or centrifugal seals are resorted to, with attendant objections to each. Basically, the first causes dilution of pulp handled and can require extensive as well as expensive seal water supply systems. Centrifugal seals limit the application of the unit by limiting the inlet pressures and by requiring more power to operate the unit.

Materials of construction are varied. Usually the manufacturer tries to produce a material that will handle the greatest amount of material for the lowest cost per ton handled. Contrary so some beliefs, hardness of material is not necessarily the best answer.

With large gravel, manganese steel will work-harden and provide long life. With fine sand, manganese will cut out like cheese.

Ni-hard types of material will quite consistently resist abrasion well, but there can be so many variables that enter into the production of Ni-hard-type castings that such castings from two different foundries will not necessarily produce equal records. Laboratory control, chilling and finishing are important and result in high cost per unit.

White iron or good quality grey iron castings, with certain new alloying elements added, produce excellent results under sand pumping service.

Much progress has been made with the use of rubber, both natural and synthetic. Here is the real answer to today's problem of handling abrasive mixtures in chemical solutions.

Rubber is as good as, if not better than, the best corrosion resistant materials as well as being cheaper. At the same time, it will resist abrasion better by far than any known metallic substance as long as there exists a true abrasive action, and there is no tearing or cutting from large solids.

Hardness and softness of rubber also enter the picture. A rubber pump part must necessarily be soft to resist abrasion. On the other hand, it must be hard enough to resist stretch and distortion under speed.

In a recent issue of one of the mining publications there appeared an article on the use of rubber lined pumps. While of general nature, it is an up to date account which should be of interest to all.

Thickness of rubber sections, medium of application (whether fixed or loose) and type of rubber (whether crude or synthetic) are all points of controversy among manufacturers and users. Each has certain advantages over the other, each is a matter of opinion and each in turn is subject to conditions under which the equipment is to be operated.

Mine Pumps

Mining of the underground type, for the most part, will use multi-stage centrifugal pumps capable of handling reasonable volumes against high heads. Here one must be careful to provide a unit which is of such material to resist corrosion and having done so must provide means of keeping all solids from the pump. This is true because most corrosion resistant high head pumps are of soft material and susceptible to abrasion.

Multi-stage centrifugals owe their success to close tolerances, perfect hydraulic balance and absolute sealing between stages.

Attempts to handle water containing solids in multi-stage centrifugals has proved disastrous.

Just about the only solution for such conditions lies in the use of a multiplicity of single stage centrifugals specifically designed to withstand abrasion.

Underground mine dewatering has recently brought about the use of specially built deep well type pumps involving as many as twelve stages to overcome the high heads (Calumet & Hecla).

In one Eastern enterprise a number of pumps totalling 18,000 gpm capacity are being used to reduce the

Table IV. Pipe Friction Loss for Water

(Wrought-iron or steel Schedule 40 pipe in good condition)

Dia, in.	Flow, gpm	Velocity, ft per sec	Velocity head, ft of water	Friction loss, ft of water per 100 ft pipe
2	50	4.78	0.355	4.67
2	100	9.56	1.42	17.4
2	150	14.3	3.20	38.0
2	200	19.1	5.68	66.3
2	300	28.7	12.8	146
4	200	5.04	0.395	2.27
4	300	7.56	0.888	4.89
4	500	12.6	2.47	13.0
4	1000	25.2	9.87	50.2
4	2000	50.4	39.5	196
6	200	2.22	0.0767	0.299
6	500	5.55	0.479	1.66
6	1000	11.1	1.92	6.17
6	2000	22.2	7.67	23.8
6	4000	44.4	30.7	93.1
8	500	3.21	0.160	0.424
8	1000	6.41	0.639	1.56
8	2000	12.8	2.56	5.86
8	4000	25.7	10.2	22.6
8	8000	51.3	40.9	88.6
10	1000	3.93	0.240	0.497
10	3000	11.8	2.16	4.00
10	5000	19.6	5.99	10.8
10	7500	29.5	13.5	24.0
10	10,000	39.3	24.0	42.2
12	2000	5.73	0.511	0.776
12	5000	14.3	3.19	4.47
12	10,000	28.7	12.8	17.4
12	15,000	43.0	28.7	38.4
12	20,000	57.3	51.1	68.1

Table V. Resistance of Fittings and Valves

(Length of straight pipe, ft, giving equivalent resistance)

Pipe size, in.	Std ell	Med-rad ell	Long-rad ell	45-deg ell	Tee	Gate valve, open	Globe valve, open	Swing check, open
1	2.7	2.3	1.7	1.3	5.8	0.6	27	6.7
2	5.5	4.6	3.5	2.5	11.0	1.2	57	13
3	8.1	6.8	5.1	3.8	17.0	1.7	85	20
4	11.0	9.1	7.0	5.0	22	2.3	110	27
5	14.0	12.0	8.9	6.1	27	2.9	140	33
6	16.0	14.0	11.0	7.7	33	3.5	160	40
8	21	18.0	14.0	10.0	43	4.5	220	53
10	26	22	17.0	13.0	56	5.7	290	67
12	32	26	20.0	15.0	66	6.7	340	80
14	36	31	23	17.0	76	8.0	390	93
16	42	35	27	19.0	87	9.0	430	107
18	46	40	30	21	100	10.2	500	120
20	52	43	34	23	110	12.0	560	134
24	63	53	40	28	140	14.0	680	160
36	94	79	60	43	200	20.0	1000	240

water level so that development work can progress. It is interesting to note that at this same property, in the time of President Grant, one of the largest Cornish pumps ever built could not hold its own and ultimately was the reason for abandonment of the project.

Drives for Pumps

Today, electric motors drive most centrifugals. Steam, gas and hydraulic turbines, gasoline, gas and diesel engines, are also used.

Factors affecting drive choice include pump and driver rpm, service conditions, pump characteristics, availability and cost of power, and physical details of the installation.

Driver speed may be limited to a certain band, as in diesel and gas engines. This band may be above or below ideal pump speed for job conditions. Where a pump runs continuously, a speed increaser or decreaser is usually warranted. For units used only occasionally as in standby service, a compromise pump design is often chosen, saving cost and complication of a speed changer.

Electric motors for pump drive in the U.S. most often are full-voltage-starting ac units, though some dc motors find use. Generally, squirrel-cage motors are used, but synchronous and wound-rotor motors are also applied.

Recent development in canned and axial-air-gap sealed motors are almost certain to have a major influence in design of future small pumps. With some canned motors, straight-through flow is obtained, considerably simplifying piping connections. Axial air-gap motors shrink to almost pancake thickness, allowing easy installation and care. Both are leakproof, important in many process jobs.

Canned motors appear to have a bright future in process and atomic-energy applications handling water at high temperatures and pressures. They also handle liquid metals.

The electromagnetic pump has no conventional driver. Instead, in the Faraday type, a heavy current is made to flow through the fluid (liquid metal), current entering the pipe wall through a brazed joint. Thus we're at the stage where raw energy, applied directly to the liquid, moves it from one point to another.

Starting torque. Returning to today's more conventional practice, we find that normal-starting-torque motors are entirely adequate for starting centrifugals, even with discharge valve open. Starting torque from rest seldom exceeds 15-20% of normal operating torque. It is usually highest in a sleeve-bearing pump that has long been idle.

Overloading an electric motor is possible if pump horsepower increases with a change in capacity. With a steam turbine, overloading is impossible because with a fixed throttle position, turbine speed is always such that pump torque equals turbine torque.

Internal-combustion engines may be rated for continuous load at rated speed, or for load at wide-open throttle, or for both. Most engines rated on continuous load will carry an overload. In any case, pump characteristics should be carefully studied before the driving engine for the installation is selected.

Variable-speed operation of centrifugals offers many advantages where varying capacity, head, or both, is needed. Since pump operating condition is fixed by crossing of its H-Q curve with system-head curve, only way to alter operating condition of a constant-speed unit is to change system by throttling. On many jobs it is more practical and economical to vary pump speed.

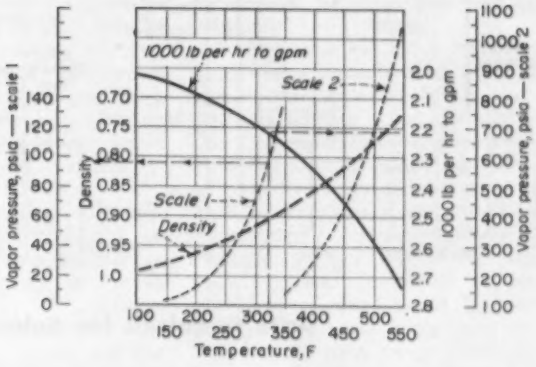
An economic study is usually needed to decide between variable and constant speed for given service. Power saving of variable speed may be more than offset by higher cost to be written off over unit's life. In boilerfeed service, allow for useful heat from power losses of throttling.

Table VI. Typical Centrifugal-Pump Rating Table

Size	Gpm	Total head, ft 10	15	20	25	30
2C	100			1000-.8	1060-1.0	1150-1.2
	150			1070-1.2	1150-1.5	1240-1.7
	200				1290-2.1	1360-2.4
3CS	150	750-.53	850-.78	950-1	1030-1.2	1100-1.5
	200		950-1.1	1010-1.4	1100-1.7	1170-2
	250			1170-1.9	1190-2.3	1260-2.6
	300					1400-3.5
3CL	200	690-.63	800-.95	910-1.3	1010-1.6	1110-2.0
	300	870-1.2	950-1.6	1000-1.9	1100-2.4	1170-2.8
	400			1200-3.1	1230-3.7	1290-4.1
	500					1490-5.8
4C	400	750-1.3	850-1.8	940-2.4	1040-3	1120-3.7
	600			1080-4	1170-4.6	1210-5.5
	800					1400-8.4
1¼D	25		617-.21	707-.03	778-.40	845-.51
	50		680-.37	760-.49	865-.63	900-.76
	75			856-.78	916-.94	980-1.1
	100					
	125					
	150					
2DL	150		820-.93	850-1.1	930-1.35	990-1.6
	200			970-1.8	1040-2.1	1080-2.3
	250					
	300					

Example: 1080-4 indicates pump speed is 1080 rpm, actual input required to operate pump is 4 hp.

Aids In Planning A Piping System



THESE CURVES show vapor pressure of water at different temperatures, and give conversion factors for flow

Automatic Controls on Pumps

Automatic controls on pumps are not new. They may, however, be divided into two classes. The first is the simple "on-off" control; the second is the control that makes the pump respond to a certain condition.

If only volume, head, and concentration of solids are involved, and if you are using a centrifugal pump, the only question is one of finding the most economical means of varying the speed of the centrifugal pump.

Actually, there is nothing new in the control field other than the adaptation of known means to your particular problem.

Be it thickener underflow, tailings disposal, filter feed, or a number of other phases of the metallurgical field, first you must decide what it is you are attempting to do.

The pump will do the job if it is told what to do. The only problem is the adaptation of equipment properly designed to accomplish that duty.

For most successful results, the device used to provide variable speed for the pump should be of the infinite variation type. Step-speed is not desirable in that it may result in "hunting," either running too fast or too slow.

Where direct current is available, the use of a dc motor, with a rheostat having many "points," will do a good job. Variable speed V-belt drives, adjustable speed ac motors, wound rotor motors, and the use of fluid couplings or magnetic couplings, all are means of providing for variation in speeds of centrifugal pumps.

Pump Selection

Five steps to better results: Selecting a pump is much like buying a hat—you have three major decisions to make. These are size, type, and best buy. But of course choosing a pump can be a far more complex problem, especially where unusual or difficult liquid conditions are met. Steps outlined below have proved suitable for typical general-purpose, process, and similar applications. Selection of other types—boiler-feed, condensate-return, hydraulic-systems, etc.—usually involves analysis of factors not directly related to the pump itself.

1. Sketch layout: Trying to pick a pump without a sketch of the system layout is like a miner trying to work without his lamp. You're in the dark from start to finish. Base your sketch on the actual job, as planned. Show all piping, fittings, valves, and equipment. Mark length of pipe runs on the sketch, and be sure to include all verticle lifts. Where piping is complex, an isometric sketch is extremely helpful.

2. Determine capacity: There are many factors entering into the capacity of a pump. Data on water systems are available. Weir boxes, trajectory measurements, chip tests and die tests can help estimate water flow in open launders and closed pipe systems.

In estimating volumes of pulps to be handled, a quick formula where tons of solids, specific gravity of solids, and percent of solids by weight are known is:

$$\text{US gpm of pulp} \quad T \times 0.1675 \frac{W}{R} \frac{1}{\text{Sp.Gr.}}$$

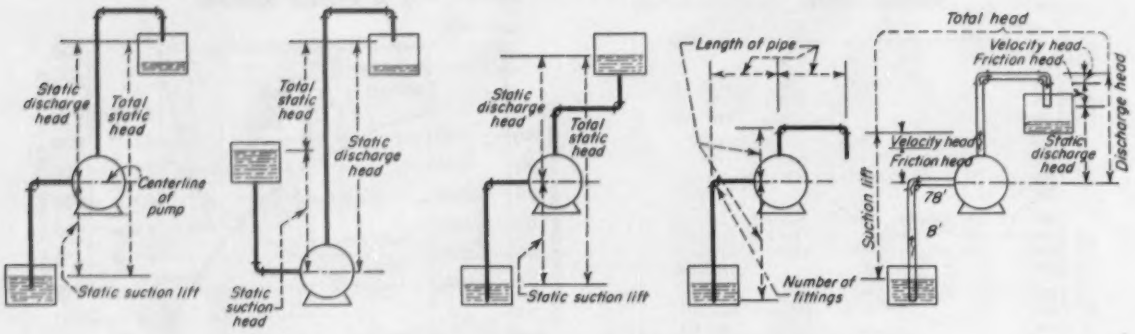
Where T = tons (2000#) per 24 hours
W = % by weight of water
R = % by weight of solids
sp. gr. = specific gravity of solids

3. Figure total head: Diagrams next page, show various heads in typical pumping systems. The definitions will help you understand the meaning of various terms. If a pump handles 500 gpm of water through 86 ft of 6 in. suction pipe (diagram at the right), and there is one medium-radius elbow having a resistance equal to 14 ft of straight pipe, total equivalent length of suction pipe is 86 14 100 ft.

Friction loss from Table IV is 1.7 ft of water per 100 ft of pipe. Velocity head is almost 0.5 ft and static suction life is 8 ft. Hence, suction life is 8 1.7 0.5 10.2 ft.

Discharge head is found in a similar way, using discharge pipe size, length of runs, and fittings in the line. Total head is the sum of suction lift and discharge head. Where you have a static suction head, as in the second hookup from the left, subtract suction head from discharge head to obtain

Typical Piping Hookups for Pumps



Data Required for Selecting Centrifugal Pumps

Inasmuch as pumping conditions vary considerably, it is necessary that definite information be supplied in order that an intelligent selection, or recommendation, may be made.

The following information should be supplied with the greatest accuracy possible:

1. Kind of service .....

   Continuous.....Intermittent.....

2. Capacity — U.S. G.P.M.....Kind of Liquid.....

   Temp. °F.....Viscosity "SSU".....Specific Gravity.....

3. Static Suction Lift.....Ft. (Exists when supply is below center of pump. Vertical distance from center pump down to level source of supply.)

3a. Variation, if any, in Static Suction Lift.....

   Minimum.....Maximum.....Dia. of Pipe.....

   Length.....No. Elbows.....90°.....45°.....

4. Static Discharge Head.....Ft. (Vertical distance from center pump to point of free discharge.)

4a. Variation, if any, in Static Discharge Head.....

   Minimum.....Maximum.....Dia. of Pipe.....

   Length.....No. Elbows.....90°.....45°.....

5. Character of Drive required.....
   If motor drive required, character of current:

   Direct Current.....Alternating Current.....

   Voltage..... Cycle..... Phase.....
   If driving unit available, specify rating and speed.

6. Remarks and special conditions not covered by above:.....

   .....

the total head. Always have the pump manufacturer check your head calculations. Then you'll be certain the pump is suitable.

Where water or other fluid not containing solids is to be handled, the problem involves the selection of a pipe size for both suction and discharge in which the friction losses are at a minimum without regard to velocity, which is of no importance.

What's Safe Velocity?

Where pumping fluids containing solids are involved, the selection of a pipe size is established from the velocity standpoint without regard to friction losses.

The velocity must be such that the solids will be kept in suspension in order to prevent plugging the pipe, and to avoid excessive power requirements met with improper velocities.

There is no known formula to give the minimum safe velocity for any one type of solid. Choice is usually a question of judgment based on experience in evaluating the following factors:

(a) Size and grading of solids.

(b) Specific gravity of solids.

(c) Concentration of solids by weight.

(d) Presence of slimes which act as a lubricant and tend to float the solids.

(e) Size of pipe line as a measure of turbulence.

The following velocities can be considered safe to use on a general basis when concentrations up to 40% by weight are involved:

Tailings containing slimes	5 to 7 ft/s
Slime-free tailings	7 to 9 ft/s
Fine graded sand	8 to 10 ft/s
Ordinary sand with fines	11 ft/s
Coarse sand and granulated slag	12 to 13 ft/s
Gravel up to ½ in.	14 ft/s
Coarse gravel	14 to 18 ft/s

The friction losses shown in Table IV are based on pipe in good condition and correspond closely to those given in Williams and Hazen's tabulations based on a coefficient of C 100 multiplied by 0.54 to make the result equal to new pipe.

Williams and Hazen's tables are all based on losses found in 15 year old pipe handling water where as in handling abrasive solids at velocities adequate to maintain suspension there exists a scouring action which keeps pipe in a condition equal to good clean new pipe.

Using friction losses based on the higher values will result in higher total heads than will exist with the net result that "over pumping" will take place.

Concentration of solids by weight has a direct bearing on friction losses as we go about 40% and materially affects friction losses in the brackets above 65%.

One practice is to increase the rate to the equivalent of C 100 at 50-55% and to go as high as C 65 in handling cement slurries in the range of 65 to 70% solids where viscosity of the pulp enters the picture.

In laying out the piping for a system designed to handle solids, it should be borne in mind that pumping either vertically and/or horizontally is much easier than to attempt to pump through lines which slope

between 15 deg and 75 deg with the horizontal. Considerable effort should be made to stay away from such slopes.

A resolution of forces develops which tends to cause the solids to drop out of suspension, roll back down the line and increase the resistance to flow. Smaller size lines in some instances will overcome this condition as a result of increased velocity.

4. Study liquid conditions: Up to this point you have determined but two requirements the pump must meet: head and capacity. Now you come to characteristics of the liquid and their effect on pump selection. Liquid heavier than water (specific gravity greater than 1) takes more horsepower to be moved from one point to another; lighter liquids require less power. Liquid temperature and vapor pressure fix the net positive suction head needed for satisfactory operation.

Unless you are thoroughly experienced with this phase of pump selection, it is best to have the manufacturer check suction conditions. Viscosity of liquid affects horsepower, head and capacity, as well as class of pump chosen. Here again, your best bet is the manufacturer. For liquids pH influences pump materials, while solids affect mechanical construction.

5. Choose class and type: Studying the layout, like trying on a hat, tells us what size (capacity and head) pump we need. This furnishes our first lead as to what class of pump is suitable. Reviewing the liquid characteristics furnishes another clue to class, because exceptionally severe conditions may rule out one or another right at the start. Sound economics dictates choosing the pump that provides the lowest cost per gallon pumped over the useful life of the unit.

Operating factors deserving recognition when deciding on class include: type of service (continuous or intermittent), running-speed preferences (high-speed pumps often cost less), future load expected and its effect on pump head, possibility of parallel or series hookup, and many others peculiar to a given job.

Once you know class and type you're ready to check these in a rating table, (Table VI). As you can see, the table lists pump capacity, head, horsepower, etc.

One important fact to keep in mind is that many large pumps are custom-built for a given plant or application. Under these conditions the pump manufacturer performs most of the steps listed above, basing his design on information supplied by the engineer on the job.

Other Considerations

I have outlined the usual steps in choosing a pump for typical industrial services. There are cases, however, where selection is better made by the pump builder.

Estimating data sheets are available from manufacturers to aid you in making a complete statement of conditions a new pump must meet. When sending such an estimate to a manufacturer it is wise to include a clear free-hand sketch of the installation.

Net positive suction head is often listed on estimate sheets and must be entered to give a complete picture of pumping conditions. This term gives pressure available or required to force a given flow, gpm into the impeller, cylinder or casing of a pump. For uniformity, npsh is stated as feet of liquid equivalent to required pressure in psi over and above vapor pressure of liquid at pumping temperature.

Every pump has its individual required npsh characteristics which the manufacturer can plot on a performance curve. Npsh at any point on the curve is head in feet of liquid pumped equivalent to pressure in psi required to force liquid into the pump. Values shown by pump manufacturer are based on tests and are regularly corrected to the centerline of the pump.

As engineer in charge of plant services, you must locate the pump and design the suction piping so available npsh is equal to or greater than npsh required by pump. Curves, herewith, give vapor pressure of water at different temperatures. They also give conversion factors for changing flow from lb per hour to gpm. Both are useful in planning.

Pipe sizes for lines, where flow demand is likely to change or resistance may increase over a period of years, require careful study. If sizes only on basis of today's demands or resistance, we may find that what was once an economical installation becomes a money-waster.

Complete analysis. Though not all jobs warrant it, a pipe system can be completely analyzed for present and future operations by using pump characteristics and system-head curves. But instead of plotting one system-head curve, a series, one for each operating condition, is plotted. Study of these will show just what you may expect from a given pump today, tomorrow, and five or more years from now. This is a job for the engineer in the plant and it deserves more attention than it usually receives.

Bin Design

(*Continued from p 85*)

should be allowed to settle and compact thoroughly. The weight of the flowing material is then well supported by the crater, and pressure within the flowing material is low. When filling out a new bin, flow difficulties due to doming may be encountered at first, until the crater has compacted. This may take hours or days.

A stable crater needs firm support from the hopper walls. The slope of the walls that gives satisfactory support depends on the size of the largest particles of the handled material and on the shape of the hopper opening. A run of mine or minus 8-in crusher product requires a hopper slope of not more than 30 deg. A flat bottom is better. As particle size is reduced, material can build up on a 45 deg and 50 deg slope. A hopper with a slot opening provides less support to a crater than one with a round or square opening.

An illustration of the importance of a stable crater in the prevention of doming is given in Fig. 8, which shows a bin storing run of mine ore. At first, this bin was built with a 45 deg hopper (a). This proved unsatisfactory: flow was constantly interrupted by doming within the hopper. The ore could not build a permanent crater on a 45 deg slope. Later the floor of the bin was rebuilt flat, as at (b) and all the trouble with flow disappeared.

When dead weight of the crater is objectionable, or when self-clearance is required, the hopper must be sufficiently steep; ledges can then be mounted on the hopper walls to provide sufficient grip and vibrators can be used for final clean out.

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Metallurgical Types of Uranium Ore

(Uranium extractions only considered in this table)

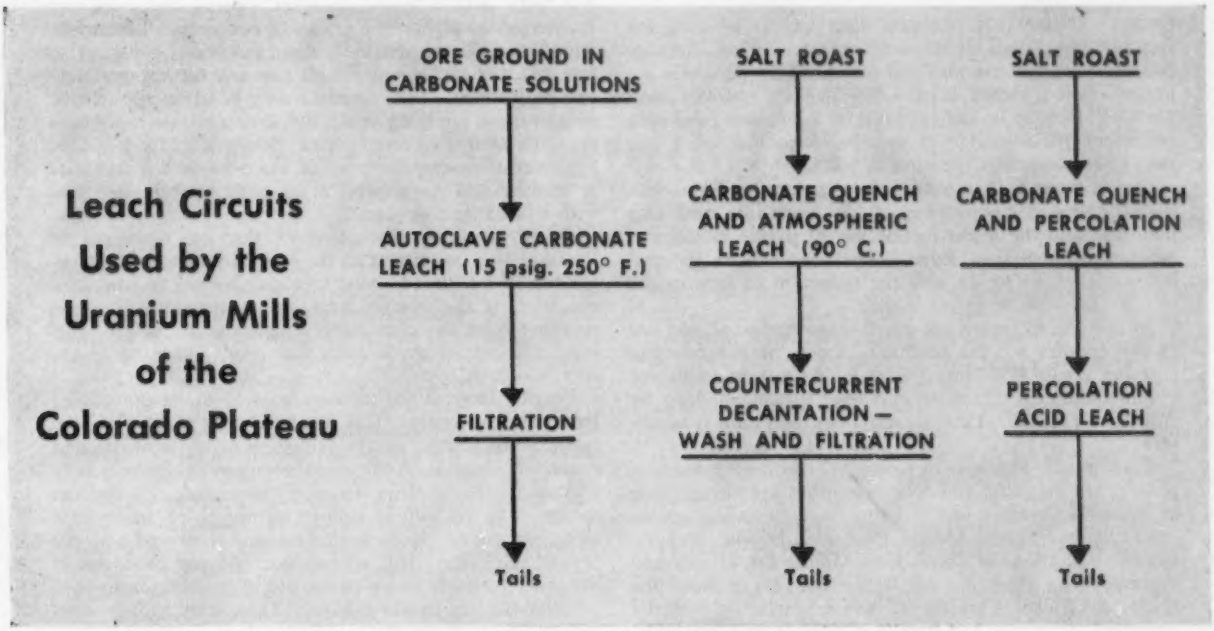
METALLURGICAL TYPE	PROBABLE FORMULA	RECOMMENDED EXTRACTION Acid Leach	Carbonate Leach	REMARKS
1. Pegmatite (betafite, euxenite, samarskite, brannerite, davadite, etc.)		CX		Uranium bearing minerals of the rare earths and Co, Ta, Ti, Th, generally refractory.
2. Primary vein pitchblende, no visible sulphides	$xUO_2.yUO_3$	BX	BN	
3. Pitchblende with other metals, scattered sulphides		BX	BN	
4. Pitchblende with other metals, many sulphides		BX	BN	
5. Uranophane	$CaO.2UO_3.2SiO_2.6H_2O$	A		
6. Uraniferous fluorite	UO_2?	C		Requires destruction of fluorite mineral.
7. Autunite	$CaO.UO_3.P_2O_5.nH_2O$	A		n usually 8-12.
8. Schroeckingerite	$Ca_3Na.UO_3.CO_3.SO_4.F.10H_2O$	A		Difficult liquid-solid separation.
9. Roscoelite (vanadium mica)	$HgK(Mg,Fe)(Al,V)_4(SiO_3)_{12}$	A	AX	Vanadium ore containing 0.04%-0.08% U_3O_8 as carnotite.
10. Carbonaceous shale	Uranium hydrocarbons	RB		Generally 60-100 ppm U_3O_8.
11. Carnotite (or tyuyamunite) low vanadium, low lime	$K_2O.2UO_3.V_2O_5.nH_2O$	A	AX	n usually 1-3.
12. Carnotite (or tyuyamunite) low vanadium, intermediate lime	$(CaO.2UO_3.V_2O_5.nH_2O)$	A	AX	(n usually 9-10 but down to 4).
13. Carnotite (or tyuyamunite) low vanadium, high lime			AX	
14. Carnotite (or tyuyamunite) high vanadium, low lime		A	AX	
15. Carnotite (or tyuyamunite) high vanadium, intermediate lime		A	AX	
16. Asphaltic type, low vanadium, low lime	Thucholite and uranium hydrocarbons	RA	RAN	
17. Asphaltic type, low vanadium, intermediate lime		RA	RAN	
18. Asphaltic type, high vanadium, low lime		RA	RAN	
19. Asphaltic type, high vanadium, intermediate lime		RA	RAN	
20. Copper-uranium (tobernite) shale	$CuO.2UO_3.P_2O_5.nH_2O$	AX		n usually 8-12.
21. Copper-uranium (tobernite) sandstone		AX		
22. Uraninite, low vanadium, low lime	$xUO_2.yUO_3$	A	AN	
23. Uraninite, low vanadium, intermediate lime		A	AN	
24. Uraninite, low vanadium, high lime			AN	
25. Uraninite, high vanadium, low lime		A	AN	
26. Uraninite, high vanadium, intermediate lime		A	AN	
27. Uraniferous lignite	Uranium hydrocarbons	RB		Generally 50-100 ppm U_3O_8, but some deposits contain up to 0.10% U_3O_8.

LEGEND

Low vanadium ..... <0.75% V_2O_5
High vanadium ..... 0.75% V_2O_5 and greater
Low lime ..... <6.00% $CaCO_3$
Intermediate lime ..... 6.00%-18% $CaCO_3$
High lime ..... >18.00% $CaCO_3$

Note: Not all major uranium minerals included; only those which are predominant to date and which must be considered for present and future processing plants.

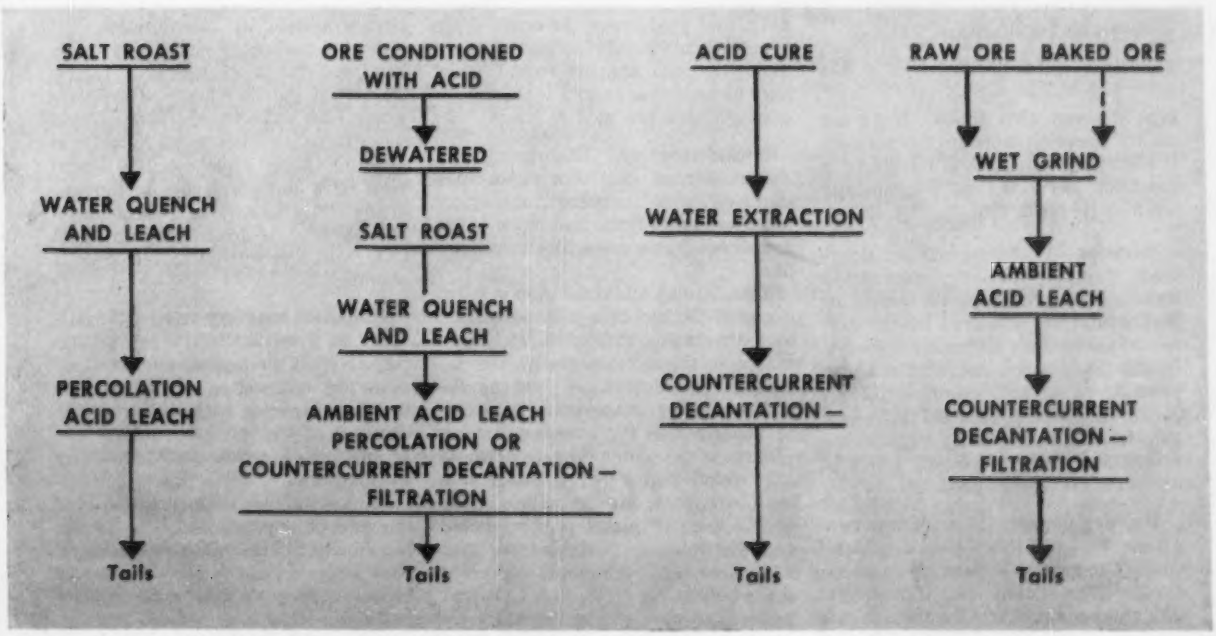
A—Uranium easily solubilized.
B—Requires moderate conditions for uranium dissolution.
C—Generally refractory. Requires vigorous treatment for uranium dissolution.
R—Ore requires roasting to remove carbon.
N—Oxidant required.
X—Oxidant beneficial.


Leach Circuits Used by the Uranium Mills of the Colorado Plateau
ORE GROUND IN CARBONATE SOLUTIONS
AUTOCLAVE CARBONATE LEACH (15 psig. 250° F.)
FILTRATION
Tails
SALT ROAST
CARBONATE QUENCH AND ATMOSPHERIC LEACH (90° C.)
COUNTERCURRENT DECANTATION — WASH AND FILTRATION
Tails
SALT ROAST
CARBONATE QUENCH AND PERCOLATION LEACH
PERCOLATION ACID LEACH
Tails

Uranium Metallurgy Highlights

FIRST STEP IN OBTAINING a uranium concentrate is to get the mineral in solution. Once in solution, there are effective methods for recovering uranium, selectively or as a sludge or precipitate brought down by pH adjustment. This precipitate is then treated chemically to produce a high grade concentrate. There are problems in uranium recovery from solutions: problems of techniques and economics, of slimes and liquid solid separations. Generally speaking, however, once uranium is in solution, it may be considered "in the can" for all practical purposes.

Capsuled on these pages are the methods of getting various Colorado Plateau ores into solution. For full details, see *E&MJ* September 1954 or write for a reprint (price 50¢).



Fluidization

(*Continued from p 75*)

design. Customarily, stainless steel has to be used for various parts such as tuyeres, transfer pipes, thermocouple wells, pressure taps and so on. If temperatures are to be carried higher than 1,000 deg C, stainless steel parts will have to be designed out of the reactor, and only refractory parts used. It can be done but there just hasn't been sufficient occasion as yet.

One of the very large tonnage applications for FluoSolids is in the magnetic conversion of low grade iron ores, also flue dust, and the direct metallizing of pyritic calcines or other sources of iron oxide. These have been grouped because all have to do with the reduction of iron oxides to a lower oxide or to the metal.

At the risk of repetition, our future supplies of iron ore in this country are the taconites, jaspers, iron formation, carrying 20 to 40% iron. This is too low in grade for pyrometallurgical treatment in a blast furnace, at least by American practice. Consequently, concentration is necessary.

Considerable tonnages of taconites or iron formations in general are magnetic and four operations are either going or in the construction and planning stage on such magnetic ores. Benson Mines, Mesabi Iron, Erie Mining, and the taconite operations of Oliver Iron Mining Co. all fall into this category. There are still larger tonnages of these low grade iron reserves which are non-magnetic or partially magnetic. In a few instances it is possible to apply flotation but only a very few deposits will respond to this treatment.

By far the larger tonnages of such low grade deposits are amenable to magnetic conversion and subsequent concentration by conventional magnetic flowsheets such as are in use for the magnetic taconites. Much work has been done in various laboratories, such as the Dorr Laboratory at Westport, Battelle Institute at Columbus, and elsewhere, on reduction roasts followed by magnetic concentration according to various flowsheets. Where the iron is present as oxides, there seems little doubt but that magnetic conversion and concentration is the final answer. While results will vary with different ores, of course, the iron unit recoveries are higher, the grades of concentrate are higher, with lower silicas, and the tailing analysis is generally so low that it is hardly conceivable that any further treatment can be justified. Figures could only be given for specific ores to mean anything at all, but almost always the results are outstandingly better than flotation. In addition, agglomeration by pelletizing of the very fine concentrate is cheaper and easier with a magnetic concentrate, than with a hematite concentrate.

Other interesting variations of this are treatment of the large lean ore dumps on the Mesabi Range, and the upgrading of flue dust at blast furnace plants. The latter carries with it the greater iron output per blast furnace, resulting from the considerably higher grade of the magnetic concentrate made from flue dust, compared to the latter's original grade.

Finally, there is the ultimate goal of direct metallizing from the iron oxide. This has been tried many times by many investigators, always falling short of technical and economic success. Today one company is commercially producing sponge iron from pyrites calcine. On the sponge iron the soluble copper in mill pulps precipitates as cement copper, to be floated out and recovered with the copper sulphides. This sponge iron is being produced in Bruckner furnaces but with the aid of fluidization to control the sulphur in the calcine. True, only a 50% conversion is being sought at present, but undoubtedly this will be improved. There is also the possibility of making the 50% or more conversion directly by fluidization.

These are the principal potential applications for fluidization as they appear today. Much has to be done to achieve successful commercial application in many of these fields. In other fields, pilot or commercial units are in the course of construction or about to start up. Some, of course, are at present simply a gleam in a researcher's eye, but all have important possibilities, and can very well greatly improve our technology.

Chemical Techniques

(*Continued from p 55*)

kept at about 25% solids. If it's too dilute, retention time in the aerators is effectively reduced. If the slurry is too thick, aeration, and consequently leaching, is inefficient.

Aeration by compressed air delivered through specially constructed turbo-agitators oxidizes the nickel so that it may be dissolved by the ammonia-ammonium carbonate solution. In the leach tanks, chemical reaction produces a soluble complex nickel-cobalt salt. Iron is oxidized to ferrous then ferric form, forming a gelatinous precipitate, ferric hydroxide, which is deposited on tailings particles.

Washing the pulp takes place in two parallel banks of four 110-ft dia thickeners. The process is standard countercurrent decantation (see flowsheet) with ammonia added in the third thickener. End products of the washing are a pulp with virtually no nickel, but a high ammonia content (which must later be recovered) and a solution containing about 1% nickel.

Nickel recovery. This nickel solution is given a final shot of air in a standard aerator to precipitate any remaining iron as ferric hydroxide. This and slimes are removed by a Sweetland filter.

The clarified nickel solution is introduced at the top of a still, designated as the ammonia stripper, while steam enters at the bottom and passes up through the downward flow of the nickel solution. Ammonia begins to be vaporized in the bubble cap trays and when the ammonia gets down to 2%, nickel begins to precipitate as a basic carbonate. At the bottom of the 40-ft tower, all nickel is precipitated and the solution contains less than 0.1% ammonia. Ammonia vaporized in the bubble cap trays, plus CO_2 and steam, pass over to the ammonia recovery system of this process.

Nickel carbonate solution is thickened and filtered in the circuit clearly shown on the flowsheet. The thixotropic filter cake (to the eye it would seem to contain not more than 10 to 12% moisture, while actually it contains 67% moisture) goes to the oxidizing kiln where water, both chemical and physical, is driven off along with CO_2, and a powdered nickel oxide is obtained.

Ammonia recovery from tailings is made in a special still. The tailings pulp is first preheated and retained until the magnesium precipitates on the pulp particles, rather than on the elements of the still. About 295 tons of ammonia are recovered here every working day.

Overall ammonia consumption is at the rate of approximately 5.5 lb per ton of ore to the reduction furnaces. Now under way at Nicaro is a 2-year expansion program to increase capacity by 75%.

Guides to the Guidebook

NOW THAT YOU HAVE HAD A CHANCE to study this guidebook, we'd like to tell you a few interesting things about some of the authors who have prepared sections of this issue, also something about the amount of effort that went into the preparation of the manuscripts.

On page 6 of the exploration article prepared by George Fowler and his associates, you will note a caption for the map of the U.S. stating that the aggregate area of the districts producing more than 90% of the domestic gold, silver, copper, lead, and zinc during the past 50 years is less than 1,000 sq mi. This figure is not just an estimate, it is based on actual planimeter measurements of maps of productive districts.

On one occasion, Mr. Fowler was studying geologic maps of the Illinois-Wisconsin lead-zinc area in his office at Joplin, when he suddenly remarked to his secretary "I've just discovered a new ore deposit!" "How could you?" she asked. "You haven't even been out of the office."

Nevertheless, that's exactly what happened. Arrangements were made to sink a churn drill hole in the section specified by Mr. Fowler. Mud and water did not permit drilling the first hole precisely where Mr. Fowler wanted it, so offset holes were started. However, a subsequent hole drilled in the focal point of the area revealed a large orebody which has since been productive. How did Mr. Fowler figure this out? He deduced that the area was cut by an enechelon fracture pattern, and that the zone discovered lay between two flanking enechelon trends a considerable distance away which contained ore indications.

Similar examples could be cited telling how a gas formation was discovered in the Midwest through study of a coal mine map, and how a new lead-zinc property was discovered in Mexico through analysis of structural trends.

Mr. Fowler toured the Colorado Plateau uranium in 1954 and observed that many of the principles set forth in the article can also be applied in the Colorado Plateau mineral areas. That's why it is suggested that uranium geologists read between the lines.

The Cerro de Pasco Driller's Manual, p 19, is equally authoritative. Peru is now, and has been, the scene of tremendous exploration projects. Mr. Kursell, principal author of the handbook, has supervised many of the largest projects involved, and with the help of Cerro de Pasco associates set forth the practical instructions given to his staff to assure dependable samples and geologic information.

The forms in the Drillers' Manual contain the vital information that exploration teams on a porphyry copper project should obtain from churn-drill and diamond-drill operations.

Dr. Arthur A. Brant's carefully prepared manuscript on geophysics, p 25, covers the application of scientific principles to the discovery and/or delineation of orebodies in many outstanding exploration and development areas including San Manuel, Lynn Lake, southern Peru, South Africa, Flin Flon, Sudbury, and elsewhere. Applications of self-potential, resistivity, electromagnetic, radioactive, geochemical, geothermal, gravitational, magnetic and seismic methods are described, illustrated—and what's more important, appraised realistically. A well-known geologist told *E&MJ* editors recently that Dr. Brant is widely respected because he does not tend to overrate the various methods. His article bears this out.

Roger Pierce, consulting engineer with wide experience in mines in the Western Hemisphere, is thoroughly familiar with underground mine equipment, and has written books and articles on the subject. His appraisal of modern applications of mine equipment, p 33, is unique in that it contains some courageous forecasts of where the industry might go from here.

Seldom does a reader have the opportunity to review a complete account of the progress of an open-pit project from exploration to virtually complete exploitation. Mine engineer George Huseman's article on Kaiser's Eagle Mountain project, p 46, goes through all the vital steps in the life of a pit, and shows why and how plans have to be revised for economic reasons, also how actual grade and production compared with original estimates.

Friction hoisting has attracted worldwide attention during the past two years. The articles on pp 41, 42, and 43, were designed to indicate an approach to the consideration of friction hoisting vs conventional drum type hoisting.

W. B. Stephenson's article on pumps, p 86, outlines the major types of pumps available, and then tells how to select a pump. This is the information a pump application engineer has to know when he advises mine and mill operators what pumps to use where.

E&MJ readers were first introduced to the process of FluoSolids in November 1947. Since then, many applications have been developed for this new roasting technique. Theodore Counselman, who has participated in the development of FluoSolids, now presents an up-to-date appraisal of present and possible applications, p 70.

Many large Western Hemisphere open-pit operations answered questionnaires last year revealing important data on drilling and blasting practices. The tables on pp 50 and 51 show techniques and equipment used by open-pit mines moving an aggregate of more than 1-million tons of ore and waste per day.

Andrew Jenike's work in bulk-solids flow has re-

ceived widespread recognition in Canada and the U.S. He has prepared a special article for this Guidebook, p 83, streamlining major concepts of bin-flow theory, and has drawn some practical conclusions that will help mine plant operators plagued with hang-ups in bins and hoppers.

Harold L. Talbot, whose article, "Chemical Metallurgy Solves Complex, Low-Grade Ore Problems," is found on pp 52 and 53, made his debut in *E&MJ* with an excellent article on South Africa's Copperbelt in the "Mining's Greatest Era" issue (July 1953). A consulting metallurgist, headquartered in Boston, Mr. Talbot has traveled extensively in this country with particular emphasis on visits to plants employing the newer chemical metallurgical techniques. This solid background has enabled him to pack two pages with solid facts

A. B. Mindler and C. F. Paulson have been intimately connected with ion exchange developments since 1943 and 1947 respectively and as a writing team they have packed 20 years of experience into seven pages on the subject starting on p 56. Both men have traveled around the world in their work, including South Africa, Australia and the Belgian Congo and while they have covered a variety of industries, more and more they are concentrating on mining. And everything a mining man should know about I Ex is in their article with an exhaustive bibliography for those who want more details.

Nathaniel Arbiter ("How to Predict Rod Mill Power Requirements," p 63), is no stranger to *E&MJ* readers nor to anyone who has more than a passing interest in grinding. As a top notch teacher, research man and consultant, Prof. Arbiter has parlayed imaginative thinking and wide experience into important contributions to mineral dressing. None of his previous contributions is more provocative than the subject with which he deals in this issue—an entirely new approach to the problem of predicting power requirements of grinding units. And mark dimensional analysis down as a research tool that is going to see more and more service in the mineral industry.

C. Kremer Bain is a talented engineer whose success is due in no small measure to his ability to think not only in terms of forces and structures, but in terms of people. His patented shaft sinking method, for example, has been responsible for the sinking of three shafts, 2322 ft, without a lost time accident. Those familiar with Mr. Bain's work know that this is no accident. On p 76 Mr. Bain discusses modern mill design and how it is illustrated at Indian Creek. Every mill man will find there ideas that are worth a second look. Mr. Bain is now engaged in consulting work with a home office in St. Louis.

E. H. Tucker, an engineer with degrees in both mining and electrical engineering, is a trouble-shooter. He's a long range commuter from his Grass Valley (Calif.) home to any place in the world where his combination of mining and electrical talents are needed, and these places are many. Mr. Tucker's experience from stope to chemical-metallurgical plant qualifies him to give the straight-from-the-shoulder advice on your electrical problems. Electrical engineer in the mining game, or miner responsible for electrical installations, you'll find good reading on pp 80 through 82.

End of the Guidebook Editorial Section

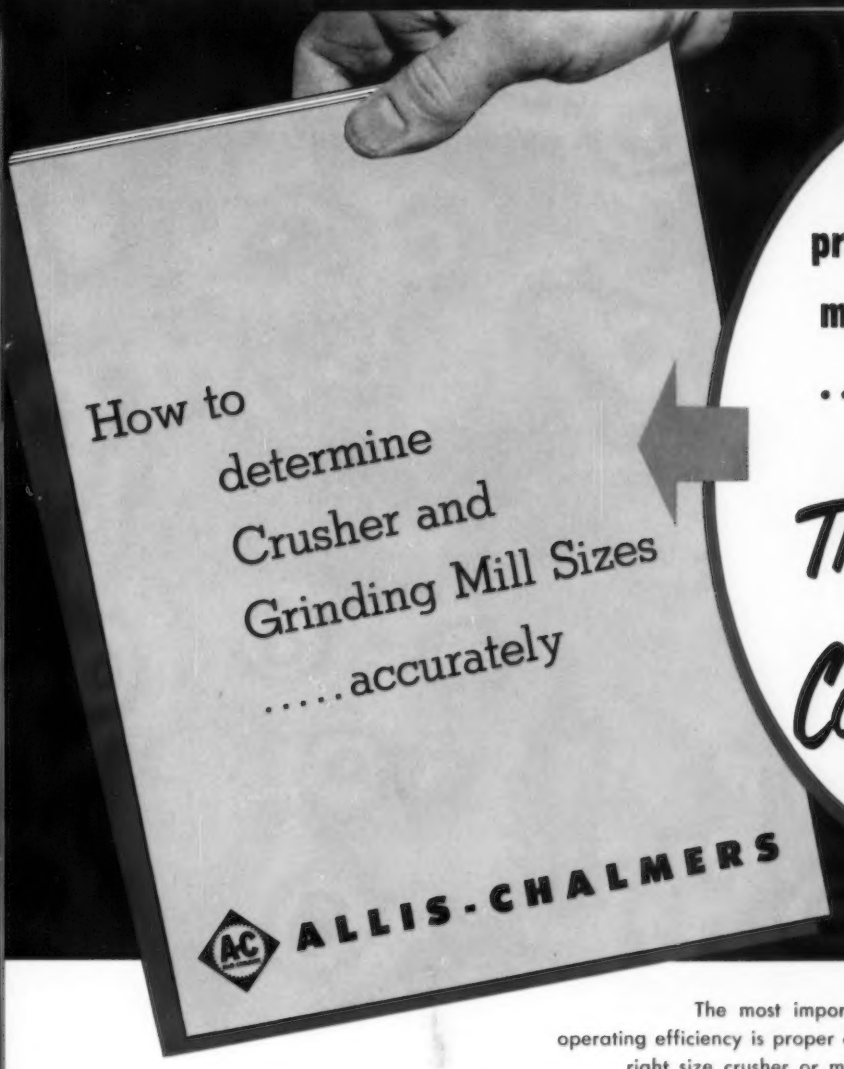
Part II of This Guidebook Issue

THE FOLLOWING PAGES give you a complete cross section of modern equipment, supplies and services offered to the mining industry by leading companies and manufacturers. The remainder of this Guidebook issue consists of:

1. Manufacturers' messages calling your attention to specific products and services available.

2. Buyer's Guide listing products, supplies, and services in alphabetical order, and the names of companies offering these items.

3. Manufacturers' directory listing names and addresses of companies offering products, supplies and services. Names of companies with special messages to readers in this Guidebook are printed in bold-face types, and the page numbers on which their respective messages appear are indexed in this section.



Here's the practical approach to maximum efficiency ...it's the NEW

Third Theory of Comminution

The most important consideration in obtaining maximum operating efficiency is proper application of equipment . . . selecting the right size crusher or mill for a specific job. But until the recent introduction by Allis-Chalmers of the Third Theory of Comminution, or *work index* formula, there was no scientific method of accurately determining the right machine.

This Allis-Chalmers method is a compilation of factual data obtained in over 35 years of field and laboratory testing of materials, ranges of reduction sizes, and types of equipment. Correlating this information made it possible to establish a consistent common factor called the *work index*. Knowing the *work index* you need only apply a given equation to determine required power input. The calculated power input enables you to select the proper crusher or mill.

How the Work Index Formula Can Help You

Applied to an existing machine, group of machines or complete plant, the *work index* formula will . . .

- Detect inefficiency. Indicate right size of equipment needed for maximum efficiency.
- Determine capacity for a given horsepower on correctly applied equipment.

Used on modernization planning, it will . . .

- Facilitate compiling preliminary application data. Indicate type and size of equipment needed. Tell you how much modernization or expansion will cost.

This practical formula together with more than 1200 tabulated *work indexes* is now available in a 72-page bulletin. To get your copy, see your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

See following pages for information on ALLIS-CHALMERS EQUIPMENT and TECHNICAL HELP.

ALLIS-CHALMERS

CRUSHERS

In the Allis-Chalmers line of gyratory crushers there are high capacity *Superior* crushers for primary and secondary crushing and the hydraulically adjusted *Hydrocone* crushers for secondary and tertiary crushing. Other crushers available from Allis-Chalmers include four types of jaw crushers, a line of roll crushers, and a multi-impact hammermill.

In the *Hydrocone* crusher (illustrated) hydraulic control makes possible quick, accurate size adjustment, simplified compensation for wear and fast emergency unloading. Adjustment is a one-man, one-minute pushbutton or hand crank operation.

Mainshaft assembly is supported on hydraulic jack. Oil pumped into or out of jack raises or lowers shaft.

GRINDING MILLS

Allis-Chalmers manufactures mills in a maximum range of sizes—your assurance of getting the most suitable mill for a given purpose. Mill types include:

Rod Mills—for wet or dry (4 to 20 mesh) grinding.

Ball Mills — for wet or dry (20 to 200 mesh) grinding.

Pebble Mills—for grinding with non-metallic grinding media and liners where iron contamination is objectionable.

Ballpeb and *Compeb* Mills — for fine grinds; stage grinding in multi-compartment types.

Illustrated on opposite page is a 9 by 12 Allis-Chalmers dry grinding peripheral discharge rod mill.

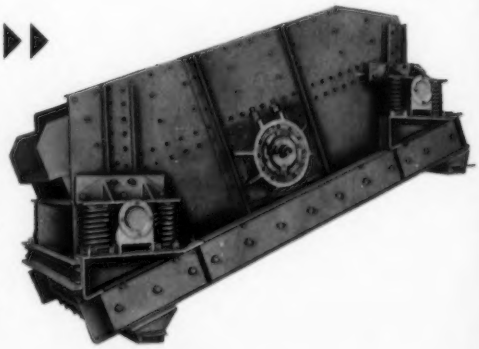
SCREENS

The Allis-Chalmers line of vibrating screens includes:

Aero-Vibe Screen — for medium to fine sizing of lump or granular material. Available with *Sta-Kleen* deck or *Thermo-Deck* heating unit.

Ripl-Flo Screen — for scalping, coarse and fine sizing. Available with *Sta-Kleen* deck (rubber balls below cloth), and *Thermo-Deck* unit.

Low-Head Screen — for wet or dry screening, rinsing or dewatering. Available with *Sta-Kleen* deck for fine sizing.



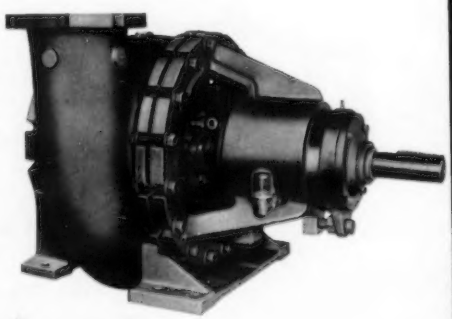
ALLIS-CHALMERS

SOLIDS HANDLING PUMP

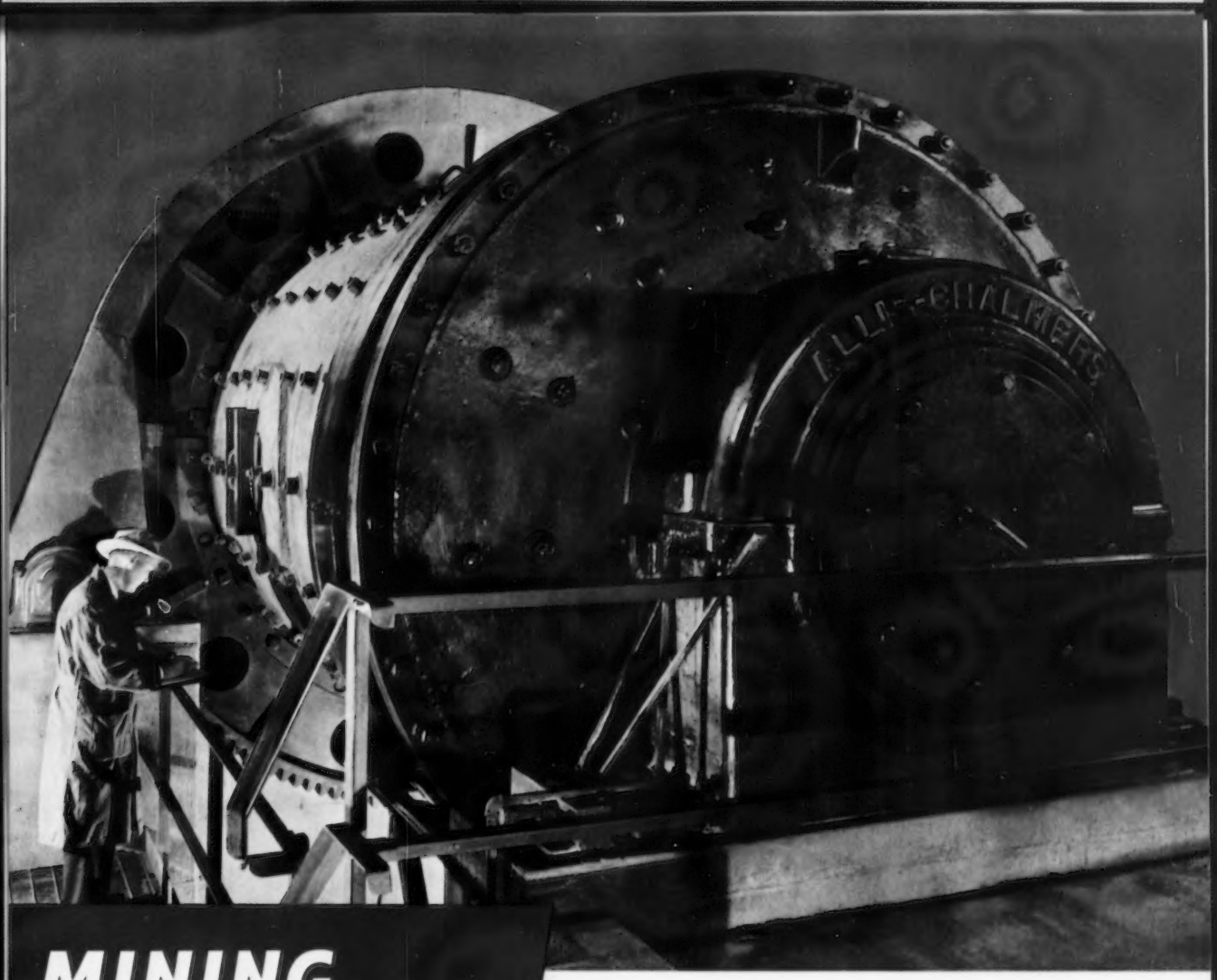
Type NRL, Rubber-Lined — This Allis-Chalmers pump is lined with special rubber compounds engineered to fit each application. Original capacity and efficiency are maintained over long periods. Records show that the Allis-Chalmers rubber-lined pump has a service life of 10 to 50 times greater than the finest alloy pump when handling finely divided, highly abrasive materials.

TYPE CW—This pump is recommended for pumping larger particles. Designed for heavy duty, the Type CW pumps are made of wear-resisting *Allisite* hard iron alloy and *Ni-Hard* nickel alloy.

In both pumps, assembly and disassembly are simplified by special construction. Inspection and repair may be made with a minimum loss of production time.



Hydrocone, Superior, Ballpeb, Compeb, Ripl-Flo, Low-Head, Aero-Vibe, Sta-Kleen, Thermo-Deck, and Allisite are Allis-Chalmers trademarks.



MINING EQUIPMENT

Recommended and Applied by Industry's TOP TECHNICAL TEAM

Whether you are planning a complete plant or a single unit replacement or addition, the Allis-Chalmers engineering team will give you or your consultants as much help as is wanted or needed.

When you specify Allis-Chalmers, your requirements are given expert consideration by men who know the mining industry. In examining your problems, these engineers and technicians not only concern themselves with correct machinery application, but with overall plant design, the evaluation of variables and the integration of interdependent equipment into a complete process. At their command is the experience gained in solving thousands of application problems, plus the finest research, testing and pilot plant facilities . . . facilities which may be used in making your operation efficient and profitable.

Unbiased Recommendations

Because A-C builds many types and sizes in a given equipment line, recommendations are completely unbiased . . . dictated only by your specific needs.

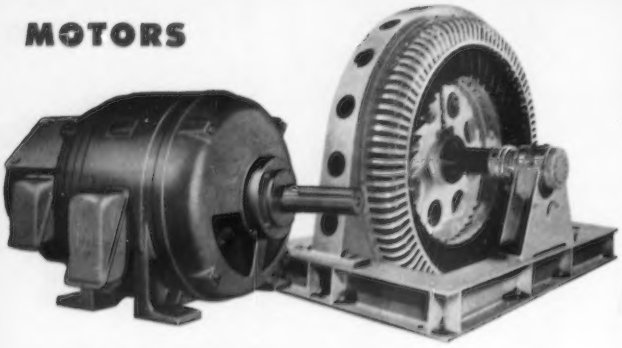
Continuous Service

Most important is the fact that Allis-Chalmers interest does not terminate with the installation of equipment. Laboratory facilities, periodic equipment checking, maintenance and fast emergency parts service, from a large stock, are yours continuously from Allis-Chalmers.

Allis-Chalmers is the one company that can equip your plant completely — processing machinery coordinated with the REQUIRED ELECTRICAL EQUIPMENT . . . machinery and equipment designed to work together, backed by undivided responsibility.

ALLIED ELECTRICAL EQUIPMENT

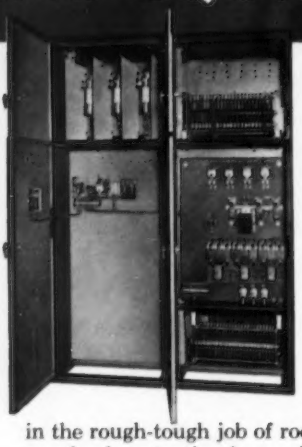
MOTORS



Allis-Chalmers builds a complete line of motors from ½ horsepower up for every industrial use. In addition to cage motors, the types most applicable to the mining industry are the wound rotor and synchronous motors.

Wound Rotor Motors are used for constant speed duty requiring frequent reversing or starting under heavy load; high starting torque applications. Ratings range from 5 hp up.

Synchronous Motors are applicable to most constant speed drives. Operating characteristics include high efficiency and the ability to improve system power factor.



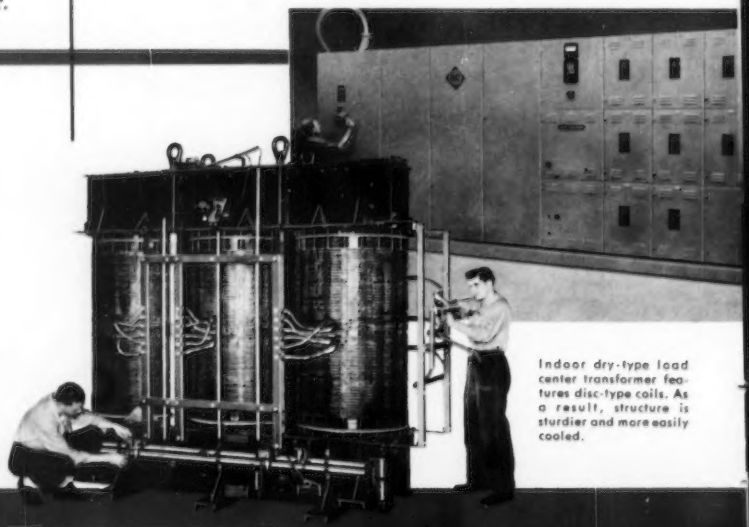
CONTROL

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has been called to solve thousands of control problems. This specialized experience is yours when you specify Allis-Chalmers control.

The control illustrated features circuit designed to cut costly down time in the rough-tough job of rock and ore crushing. *Motor overload protection* is provided by two sets of thermal overload relay. One set operates on slight overload to sound warning. Second set stops motor when temperature reaches danger point. Control is arranged so that *maximum starting torque* can be obtained at any time while motor is being started. *Jog controller* permits rocking to clear jam. *Time-delay undervoltage relay* allows riding through momentary voltage dips. On currents greater than normal load peaks, motor is disconnected through an *instantaneous current relay*.

UNIT SUBSTATIONS

Allis-Chalmers load center unit substations step down voltages . . . distribute power . . . protect circuits, equipment and personnel. Completely factory assembled, transformer, switchgear and control combinations are integrated in one attractive, easy-to-install enclosure. Compact and flexible, these units can be strategically located to bring high voltages near load centers with resultant economy in cable cost, minimum line loss and efficient voltage regulation.



Indoor dry-type load center transformer features disc-type coils. As a result, structure is sturdier and more easily cooled.

ALLIS-CHALMERS

A-4618

Allis-Chalmers, Milwaukee 1, Wisconsin

Send me the following bulletins:

☐ 25C6166L, a catalog of all A-C mining industries equipment.

☐ I would also like bulletins on ..... type of equipment

Explanation of process or problem.

.....

.....

Name .....

Title ..... Company .....

Address .....

City ..... Zone ..... State .....

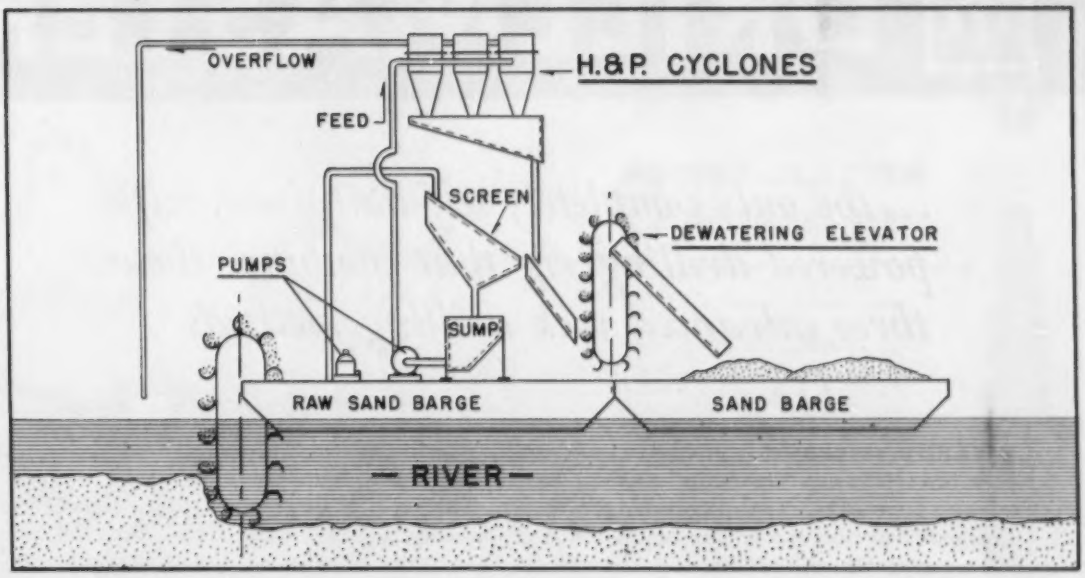
A-C ALLIS-CHALMERS

Write for Literature

Bulletin 07B6166L covers all equipment manufactured by Allis-Chalmers for the mining industries. Individual bulletins covering specific equipment lines are also available.

Heyl & Patterson Cyclones

HELP RECOVER HIGH GRADE MARKETABLE SAND



Here is another example of the versatility of Heyl & Patterson Cyclones.

A large sand and gravel company has devised a system which is recovering a substantial amount of high grade, marketable sand. It is noteworthy that all classifying and thickening in this operation are accomplished by Heyl & Patterson Cyclones.

The slurry is fed from a sump at 1500 gallons per minute to 3 standard 14" H & P Cyclones. The slurry is composed of small particles of river sand having a solids concentration of less than 4% by weight.

The waste slurry from the washing operation of the coarse sand is processed by a manifold of 14" Cyclones which recovers a substantial tonnage of +200 mesh grains and rejects the undesirable deleterious earth.

The underflow from the Cyclones averaging 75% solids by weight is delivered to the sand barge. The overflow containing the deleterious earth is thrown overboard. Write for Free Cyclone Booklet CT-954.

Heyl & Patterson, Inc.

"SINCE 1887"

55 FORT PITT BLVD · PITTSBURGH 22, PA.

Heavy Bulk Materials Handling Equipment

All The Way from Design to Erection

THIS IS IT!

The revolutionary NEW three-way

DRILLMASTER

...the only completely self-contained, self-powered drilling rig that combines these three advanced rock drilling methods

HERE in one completely integrated package is a totally new "three-way" rock drilling machine designed to speed up work and provide a range of hole sizes and drilling depths heretofore not available in a blast hole drill. The versatile Ingersoll-Rand Drillmaster embodies three combinations or methods of drilling.

Combination one utilizes the new revolutionary DEPTH-MASTER or "down the hole" drill for deep blast holes up to 6" in diameter.

Combination two is available with the POWER-MASTER a new heavy-duty hammer drill for 4¼" holes.

Combination three with the ROTO-MASTER rotary drill is ideal for rotary drilling for hole sizes up to 6¼". You can buy any one or all three of the drilling combinations to suit your own requirements.

Never before has there been a rock drilling machine that offered so much for blast hole drillers. The Drillmaster's versatility (three ways of drilling), its independent rotation, and long wearing Ingersoll-Rand Carset Bits will give you faster and cheaper drilling in any kind of rock.

Whatever your rock drilling problem, consult your Ingersoll-Rand representative. His experience is yours for the asking. Ask him or write direct for informative Drillmaster Bulletin, Form 4164.

This new eight page informative booklet will give you the complete Drillmaster story. Ask your I-R representative for a copy or write for Bulletin 4164.

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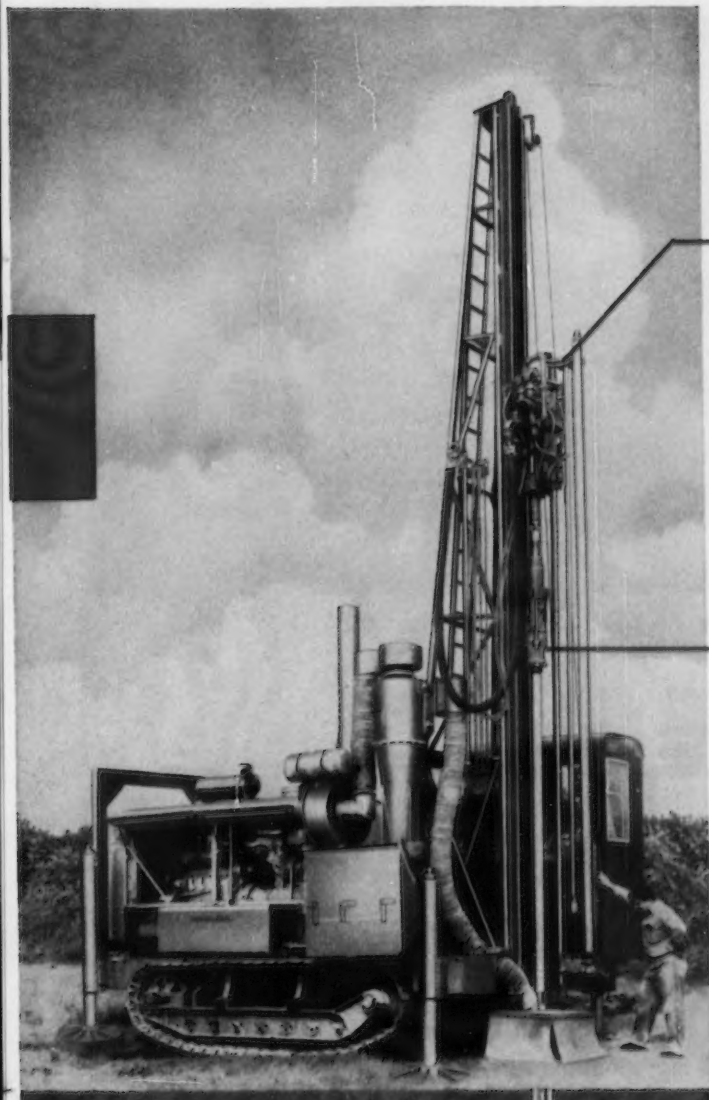
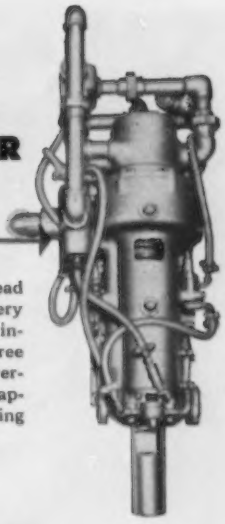
ROCK DRILLS • COMPRESSORS • PUMPS • AIR TOOLS • OIL & GAS ENGINES • CONDENSERS



ROTO-MASTER
"rotary drill"



This powerful rotary drill head is standard equipment on every Drillmaster and supplies the independent rotation for all three methods of drilling. This powerful independent rotation is appreciated by all when drilling tight or broken ground.

POWER-MASTER
"out-of-the-hole drill"

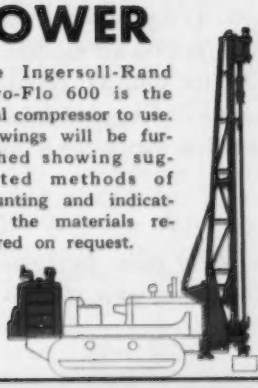
The Power-Master, a new extra heavy-duty hammer drill is the most powerful machine in its class. It provides the fastest drilling combination for 4¼" holes to 60 ft. in depth, making it second to none for construction work. It utilizes long wearing Carset Bits on proven Ingersoll-Rand rods and threads.

DEPTH-MASTER
"down-the-hole drill"

In this truly outstanding contribution to rock drilling the drill actually goes down the hole with the bit — No energy is lost in long heavy drill steels and much deeper blast holes are possible than with hammer drills. Rotation is provided by the Roto-Master and 6¼" Carset Bits are used.

TOWER

The Ingersoll-Rand Gyro-Flo 600 is the ideal compressor to use. Drawings will be furnished showing suggested methods of mounting and indicating the materials required on request.



KREBS CYCLONES

. . . sharpest classification at lowest cost

Krebs Cyclones are out-front in low cost classification thanks to a special moulded pure gum rubber liner that far outlasts any porous gum rubber or other type liner. Instances of service for a year or more without appreciable wear are not uncommon. Compare this with cases of rubber liners lasting weeks or sometimes only days as reported in literature on cyclones!

These moulded pure gum rubber liners are dense, smooth and *replacable* . . . an important factor in simplified and economical maintenance.

Krebs Cyclones are precision made with machined steel shells. Fitted with thc pressure moulded liners, their complete weight is far less than cast iron or nihard cyclones. Engineered for an idealized force pattern, Krebs Cyclones in sizes from 4″ to 30″ are available either in single or integral two stage units. Long sweep inlet and adjustable valve are standard on all models. Special designs are available for unusual classifications. All units permit a wide change of inlet size, vortex size and apex valve for changes in objectives.

★ ★ ★

Our metallurgical staff and pilot plant facilities are available on request. Details of your classifications are invited.

EQUIPMENT ENGINEERS, INC.

41 SUTTER STREET ● SAN FRANCISCO 4, CALIFORNIA

Another Way to HARD-FACE CRUSHER JAWS WITHOUT DISTORTION

A good many operators of crushing equipment consider the hard-facing of jaws a mighty ticklish job; the bugaboo being distortion resulting from welding heat. But H. D. Sutcliffe, maintenance weldor at Buellflat Rock Company in Solvang, California, has a good answer to this problem. Perhaps his method will be applicable to your operations.

Mr. Sutcliffe has a large rack on which he places a number of spare crusher jaws or segments side by side. During the course of the day skip welds are applied from jaw to jaw as time allows, using Stoody Moly-Manganese for rebuilding and Coated Tube Stoodite for the final passes. In this way welding heat is never permitted to build up sufficiently to cause warpage. The Moly-Manganese deposits are peened and wire brushed as they are laid down. By the time the jaws on the rack are finally rebuilt and hard-faced, it is time to remove the worn jaws from the crusher, setting them up for the same rebuilding treatment.

Wear on the crusher is checked at frequent intervals and plates are removed for rebuilding before serious wear occurs. With this procedure it is rarely necessary to buy replacements. The company's experience is that Stoody Moly-Manganese and Coated Tube Stoodite are regularly giving 2 to 3 times the wear of other materials previously used.

Your Stoody dealer (consult the yellow pages of your telephone directory) will be glad to give you descriptive literature on all Stoody alloys, and a copy of the Stoody Guidebook covering maintenance of all types of heavy equipment. Or you may write to the company.

STOODY COMPANY
11940 East Slauson Avenue
Whittier, California

2 Stock Answers for

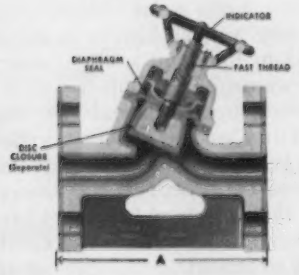
Farris X-V Series

This versatile, dependable, economically-priced hand valve is equally at home in corrosion, abrasion, vacuum or general service—wherever positive action is needed. The X-V Series disc—for positive closure—and diaphragm—for positive sealing—work independently, with only the disc exposed to pressure in the closed position, substantially increasing diaphragm life, lowering torque and providing unsurpassed vacuum service . . . No other valve does such a complete job at so little cost!

Write for Bulletin FL-154

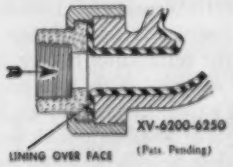
DISC for positive closure

DIAPHRAGM for positive sealing



NEW

Corrosion Resistant Union Ends



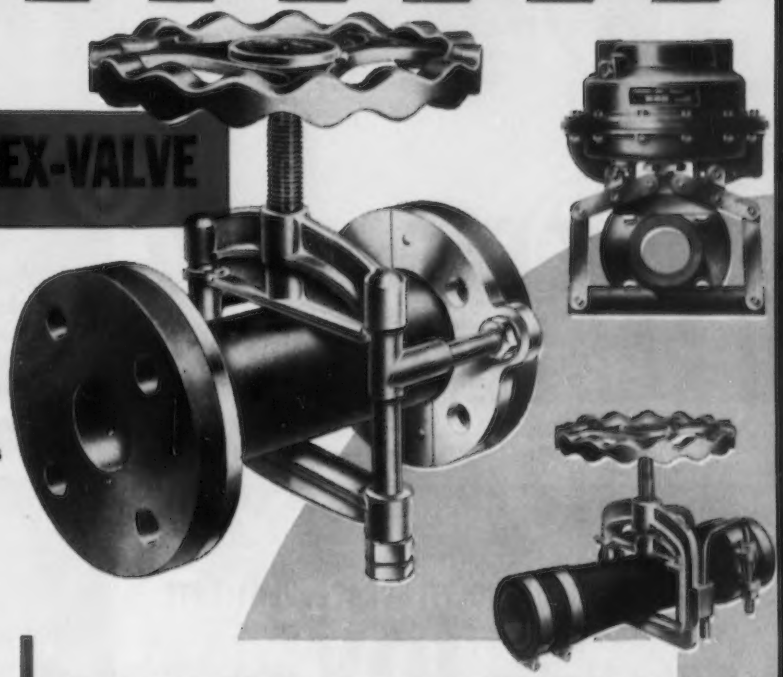
XV-6200-6250 (Pats. Pending)

X-V Series Design Features

- Realistically-Priced for Low-Cost Service
- 50% Greater Capacity than Similar Type Valves
- Only Disc Area Exposed to High Vacuum in Closed Position
- No Packing Gland to Leak. Mechanism Not Exposed
- Low Hand-Wheel Torque... Easy to Operate
- Available in Lined or Unlined Models...With Corrosion Resistant Union Ends.

Tough Valve Problems

Farris Pinch-type FLEX-VALVE



No other valve controls the flow of hard-to-handle corrosive and abrasive materials with the efficiency and reliability of the Farris Pinch-Type FLEX-VALVE . . . because FLEX-VALVE cannot plug! This is the simplest valve made—only two components—employing the fundamental principle of pinching off the rugged, flexible valve body. Case histories show batteries of these valves in severe service for more than 20 years—and still going strong!

For complete information write for Catalog FL-382

YOUR MONEY BACK

IF IT PLUGS!

Flex-Valve's Exclusive Advantages

- Will Outwear Any Metal Valve in Abrasive Service
- Full Pipe Capacity
- Maintenance Free
- Bubble Air-Tight
- Low Replacement Cost
- No Obstructions, Pockets or Internal Parts
- Available in Rubber, Neoprene, Butyl, Buna-N, Buna-S, Food Stock and Special Compounds.
- Air or Hand-operated Types

Farris

There is no compromise with experience!
There is only one FLEX-VALVE

FLEXIBLE VALVE CORPORATION

430 COMMERCIAL AVENUE, PALISADES PARK, NEW JERSEY

affiliates: FARRIS ENGINEERING CORP. • FARRIS STĀCON CORP.
FARRIS HYDROSEAL CORP. • FARRIS HYDROTORQUE CORP. • FARRIS PICKERING GOVERNOR CO.

JOY STOPERS—Lightweight and heavy-duty models with standard or telescopic feed, steel changes to 36", short overall length. Write for Bulletin 87-G.

...UNDERGROUND PRODUCTION PROBLEMS ?

DRILL, LOAD, HAUL, HOIST, SCRAPE, VENTILATE

The Modern JOY Way

Whatever your mining problem, there's a modern Joy machine to handle the job quickly, easily, efficiently.

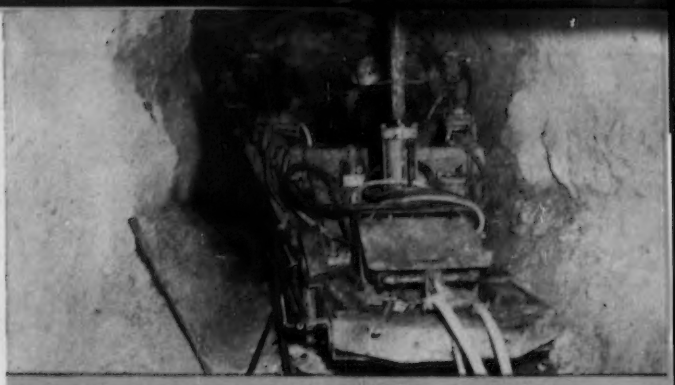
Select the equipment in which you are most interested, and write TODAY for detail-packed bulletins. ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** *In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

JOY

WSD M 53608

WORLD'S LARGEST MANUFACTURER OF UNDERGROUND MINING EQUIPMENT

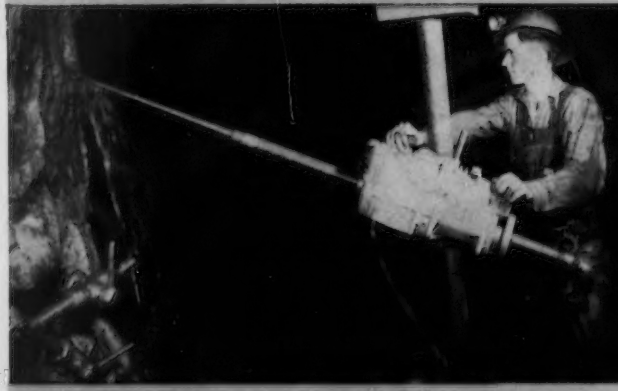
Other Joy Products—OPEN CUT BLASTHOLE DRILLS • DIAMOND CORE DRILLS • DIAMOND BITS • WAGON DRILLS • ROCK BITS • HAND-HELD DRILLS • BREAKERS • TAIL ROPE SHEAVES • CONTINUOUS MINERS • OXYGEN GENERATORS



JIB JUMBO—Track-mounted Jumbo with drills on hydraulically-controlled Hydro Drill Jibs for fast, easy drilling. Ask for Bulletin 87-F.

DRILLMOBILE—Rubber-tired, self-propelled Jumbo with drills on Hydro Drill Jibs. Long chain feeds. Bulletin 87-F.

AIR LEG—Easy-to-handle air leg with "one-hand control" built into drill backhead. Perfect in combination with Joy LM-47 Drill. Bulletin 87-M.



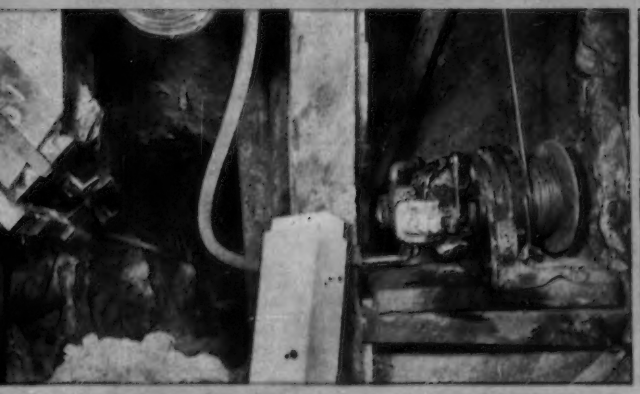
HS-15 CORE AND BLASTHOLE DRILL—Air-driven rotary drill for column mounting. In-line drive. Choice of speed ranges. Bulletin D-32.

18-HR-2 LOADER—High capacity loading machine for rock and ore. *12 tons per minute.* Ruggedly built to withstand rough usage, abrasion. Bulletin J-108.

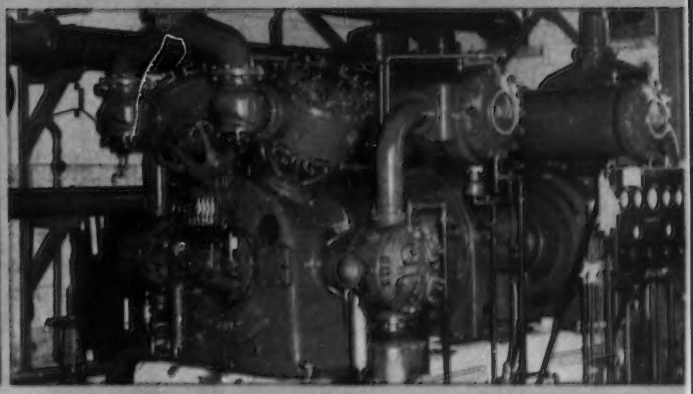
SHUTTLE CARS—Cable reel, battery, or diesel-electric types in various capacities. Extra rugged for rock and ore haulage. Bulletin J-102.

ELECTRICAL CONNECTORS—Watertight, one-piece Neoprene connectors for use with any electrical mining equipment. Sizes and styles for all uses. Bulletin B-56.

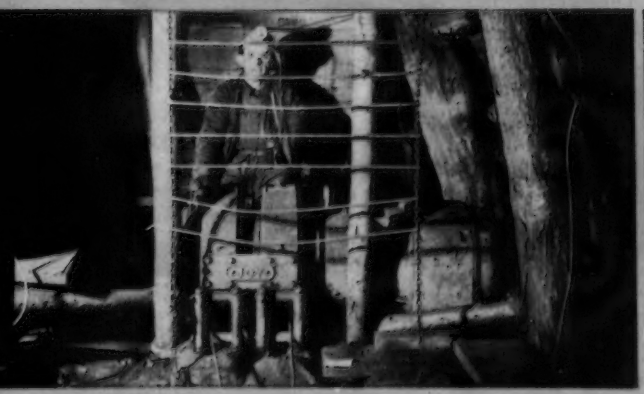
JOY CONVEYORS—Complete line of belt, shaker and chain conveyors for any underground application. Bulletin LD-102.



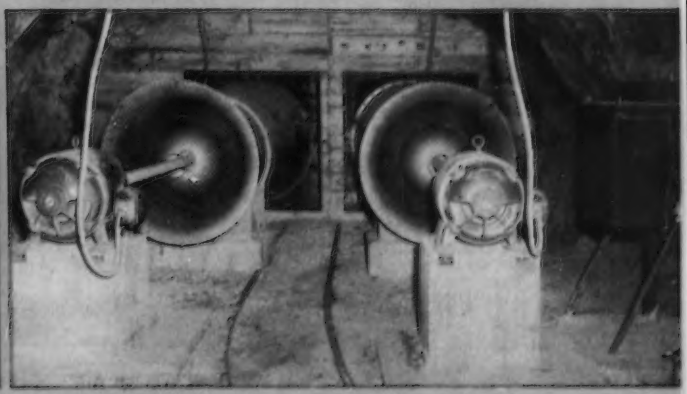
SINGLE DRUM HOISTS—Air or electric drive, lifting capacities 500 to 3500 lbs., rope capacities to 1500 feet. Bulletin 76-X. Also single and two-drum shaft hoists to 150 HP.



AIR COMPRESSORS—Dependable air power supply. Displacements from 81 to 3896 CFM. Single and two stage units for every need. Bulletin M-201.



SLUSHERS—Two and three-drum models, 5 to 150 HP, rope pulls to 15,000 lbs., air or electric drive. Bulletin 76-Y.



AXIVANE FANS—Portable blowers, adjustable-blade fans, and large mine fans. A size for every ventilating job. Bulletin J-607.

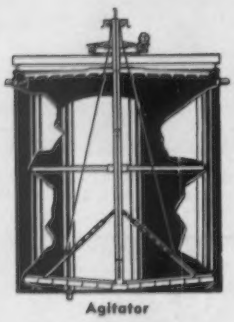
HARDINGE COMPANY, INCORPORATED

YORK, PENNSYLVANIA

NEW YORK • TORONTO • CHICAGO • HIBBING • HOUSTON • SALT LAKE CITY • SAN FRANCISCO

AGITATING

Hardinge combined mechanical and air Agitators are used to mix, agitate or store clay slurries, as well as metallurgical and chemical pulps. Compressed air is delivered to the bottom of the torque tube, (which acts as an air lift), and to various points near the ends of the rotating scrapers. Pulp is fed and withdrawn continuously or intermittently, as desired. The drive mechanism is supported on ball bearings in an oil filled, totally enclosed housing. The scraper raising winch is in easy reach and away from possible splash of pulp. Bulletin 31-D-1.



Agitator

CALCINING

Rotary Kiln

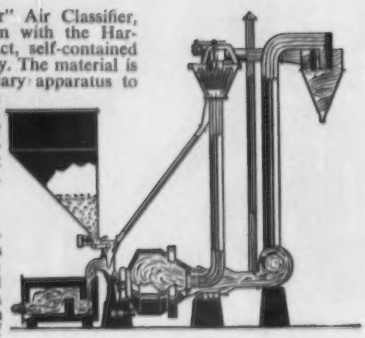
For small and medium capacity requirements, Hardinge offers the Ruggles-Coles Rotary Kiln for continuous calcining, roasting or oxidizing operations. It may be fired by oil, gas or pulverized coal. Bulletin 16-D-1.

Hardinge also makes a line of vertical shaft kilns, both direct-fired and mixed-feed types. The Keystone Lime Kiln is ideal for smaller operations using coal, coke, oil or gas for fuel. Bulletin 23-A-1.

CLASSIFYING • SEPARATING

Dry Classifiers

The Hardinge "Gyrotor" Air Classifier, operating in conjunction with the Hardinge Mill, is a compact, self-contained unit of unusual efficiency. The material is conveyed without auxiliary apparatus to any convenient location in the building. The Hardinge "Gyrotor" Air Classifier provides extremely close product control. Bulletin 17-B-1.



Air Classifier

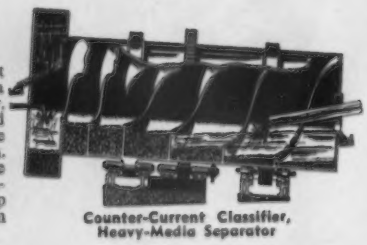
Wet Classifiers

The Hardinge Counter-Current Classifier is used for making size separations of ores and sands. It consists of a slowly rotating drum, on the inner surface of which is attached a screw flight. Will operate in closed circuit with a° grinding mill without the use of conveyors or pumps. The Hardinge Hydro-Classifier is a large-volume classifier for fine separating problems. Bulletin 39-B-1.

Hydro-Classifier

Heavy Media Separators

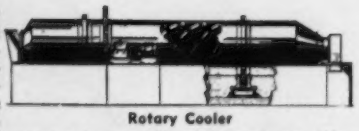
The Counter-Current unit is also used as a Heavy-Media Separator. The "Sink" is separated from the "Float" by the screw flights as shown. The unit has only one moving part, is very efficient and will start up fully loaded. Bulletin 39-B-1.



Counter-Current Classifier, Heavy-Media Separator

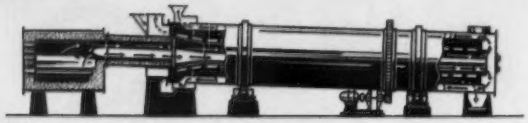
COOLING

Ruggles-Coles Rotary Coolers are employed for cooling hot materials after high-temperature drying or calcination. There are three types: the air type, utilizing an induced cool air stream; the partially submerged type (illustrated); and the water spray type with exterior sprays cooling the shell. Bulletin 16-D-1.



Rotary Cooler

DRYING



Class XB Double-Shell Rotary Dryer

There are six distinct types of Ruggles-Coles double and single-shell Rotary Dryers, designed for direct, indirect and steam heat. Bulletin 16-D-1.

Class XA—This double-shell, semi-direct-heat dryer has the highest thermal efficiency and lowest fuel consumption of any rotary dryer manufactured. Particularly adapted for coal drying.

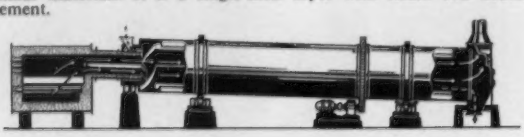
Class XB—A double-shell, indirect-heat dryer designed to handle such materials as kaolin, chalk, whiting, china clay, pigments, fuller's earth.

Class XC—A rotary steam tube dryer for drying materials that are injured by high temperature such as brewers' grain, cotton seed, starch feed, tobacco stems and corn germs.

Class XF—Single-shell, counter-flow dryer for high drying temperatures.

Class XH—A single-shell, parallel-flow dryer, especially designed to handle flotation concentrates without sticking and without excessive dust loss.

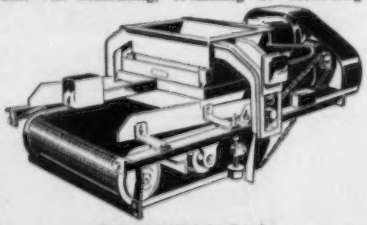
Class XW—Used almost exclusively for drying inorganic salts and similar materials. It is a single-shell dryer with steam coil heating element.



Class XH single-Shell Rotary Dryer

FEEDING

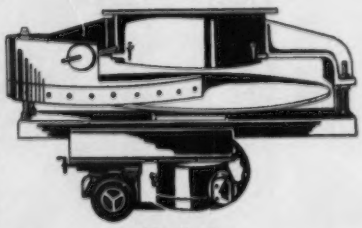
The Hardinge Constant-Weight Feeder measures by weight, not volume, thus compensating for variations due to changes in specific gravity, bulking or size of material. The feeder is quite accurate, and it affords automatic feed control for crushers, pulverizers, mixers, dryers, kilns, furnaces and conveyors. The feeder is bin-supported, requires little head room. An indicating, totalizing or recording tachometer may be attached to the feeder drive to provide a weight measurement or record of the feeding operation.



Constant-Weight Feeder

The Hardinge Disc Feeder is outstanding in its simplicity, sturdiness and ease in adjustment. Particularly suitable for handling bulky, sticky, hot materials. Economical in cost and requires a minimum of head room.

Other Hardinge regulating feeders are: the Volumetric Belt Feeder which provides uniform volume feeding control; and the Volumetric Non-Flooding Drum Feeder which employs the rotary pocket principle. Bulletin 33-E-1 describes the entire feeder line.



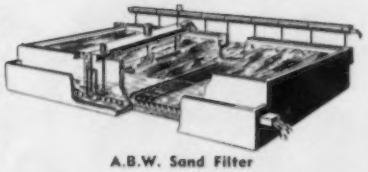
Disc Feeder

HARDINGE COMPANY, INCORPORATED

YORK, PENNSYLVANIA

NEW YORK • TORONTO • CHICAGO • HIBBING • HOUSTON • SALT LAKE CITY • SAN FRANCISCO

FILTERING



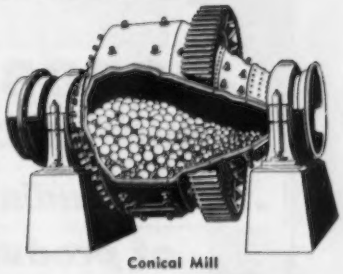
A.B.W. Sand Filter

The Hardinge Automatic Backwash Rapid Sand Filter cleans its own filter bed, a section at a time, automatically, without shut-downs or changeover. Primarily adapted to the filtering of water containing small amounts of suspended particles that cannot be properly collected in settling basins or clarifiers. Used for filtering municipal water supplies, industrial water supplies, and certain presettled industrial waste waters to permit their re-use. Bulletin 46-A-1.

GRINDING • PULVERIZING

Conical Mills

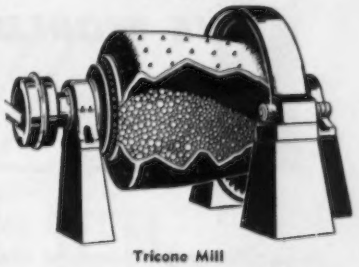
The shape of the Hardinge Conical Mill causes a rapid circulating and classifying action within the drum, which increases the capacity for power expended over other types. The range of grinding is large, due to the segregation of the sizes within the mill. The conical shape insures extreme rigidity and simplicity. Mechanical troubles are practically unknown. Sizes range from 2 feet to 10 feet with capacities from a few pounds per hour to 10 tons per hour. Bulletin 17-B-1 gives full details of dry grinding applications; Bulletin AH-389-1, wet grinding.



Conical Mill

Tricone Mills

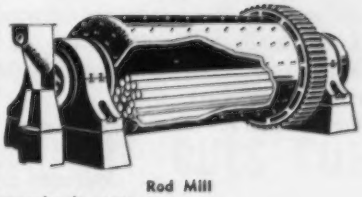
Built on the same principle as the Conical Mill, the Tricone Mill offers greater grinding volume for a given amount of floor space than any other tumbling mill built. Extremely efficient. Ideal for large tonnages. Sizes up to 12 ft. diameter. Bulletin AH-414-1.



Tricone Mill

Rod Mills

Steel rods are employed as grinding media. Ideal for producing minimum oversize in open circuit grinding. For either wet or dry grinding. Convex or conical heads reduce friction, prevent congestion of charge at the ends, and align the rods. Available with either end, or center, peripheral discharge, as well as trunnion overflow. Bulletin 25-C-1.



Rod Mill

Other Mills

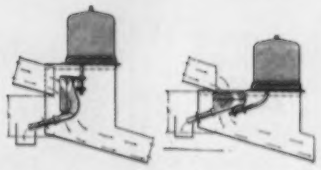
Hardinge also builds a line of cylindrical and tube, ball and pebble mills as well as batch mills.

"Electric Ear" ®

A revolutionary principle of control that automatically regulates the feed rate of a mill to keep it operating at maximum efficiency by "listening" to the sound. It compensates for changes in grindability due to variation in hardness, size of feed, etc. The product is more uniform and the mill capacity is increased 10% to 20% by its use alone. Frees the operator for other duties. Bulletin 42-1.

"Electric Ear"

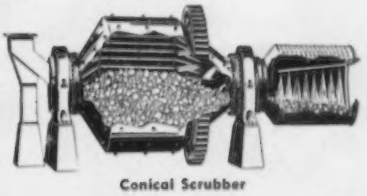
SAMPLING



Automatic Wet Samplers

The Hardinge Automatic Sampler is simple in design, rugged in construction and offers a wide selection of sampling intervals and cutter openings. Accurate, continuous and trouble-free operation. Available for wet or dry processes. Wet models illustrated; type "A" cutter (left), type "B" (right). Bulletin 47-1.

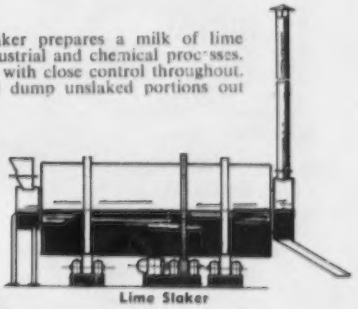
SCRUBBING



Conical Scrubber

The Hardinge Conical Scrubber cleans by mass contact and natural displacement. This action removes dirt and silt without wear on the scrubber. The classifying action of the cone holds back the large clay balls until properly disintegrated. Foreign materials, such as sticks, vegetation or large pieces of metal can do no harm. Power requirement is low, and water requirements are considerably less than that of other methods. Repair costs are negligible. Bulletin 37-A-1.

SLAKING



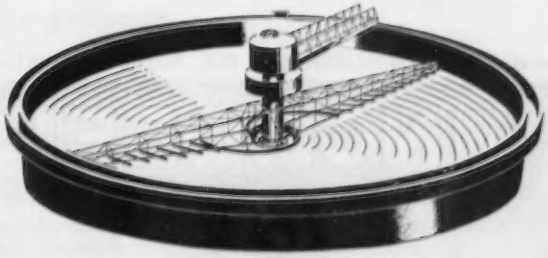
Lime Slaker

The Hardinge Lime Slaker prepares a milk of lime slurry as required in industrial and chemical processes. Operation is continuous, with close control throughout. Lifters at discharge end dump unslaked portions out of drum. Impurities and grit in the discharge can be separated by a Hydro-Classifier if desired. Bulletin 50-1.

THICKENING

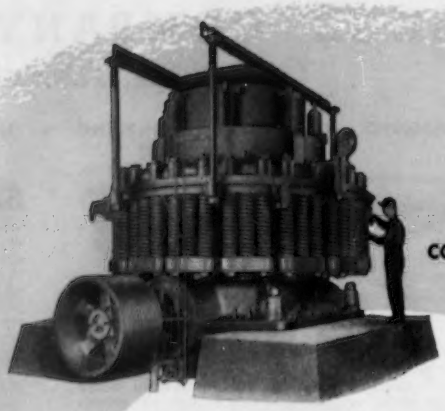
The distinctive features of the Hardinge Thickener are the spiral scrapers, which clean the bottom of the tank with each revolution, and the "Auto-Raise" driving mechanism which automatically lifts the scraper away from an overload or obstruction in the tank bottom, thus eliminating costly breakdowns and delays. Can be operated very slowly, causing a minimum of disturbance. Produces a clearer overflow and a thicker discharge than other types. Small thickener mechanisms are supported on beams, spanning the tank. The large units carry the mechanism on a central concrete pier. Bulletin 31-D-1.

Small-Diameter Thickener



Large-Diameter Thickener

SYMONS* PRIMARY GYRATORY CRUSHERS



SYMONS* CONE CRUSHERS

SYMONS "V" SCREENS for extremely fine separation

SYMONS* VIBRATING SCREENS

SYMONS* VIBRATING BAR GRIZZLIES

SYMONS* VIBRATING ROD GRIZZLIES

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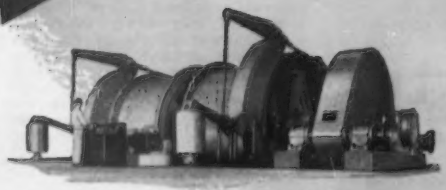
...the leading choice of producers THE WORLD OVER

NORDBERG BALL—TUBE and ROD MILLS for wet and dry grinding

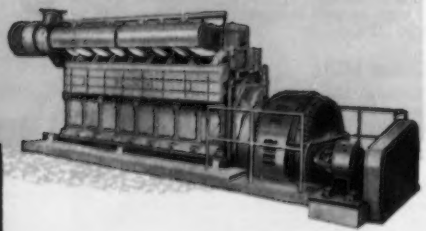
It is highly significant that wherever ores are found in quantity — efficiency-minded producers are now using, or are in the process of installing, Nordberg Mining Machinery . . . to assure maximum and continuous production at low operating and maintenance costs.

Write for literature on the machinery you need.



NORDBERG MINE HOISTS

NORDBERG DIESEL— DUAFUEL® and SPARK-FIRED GAS ENGINES from 10 to over 10,000 H.P. in a single engine.



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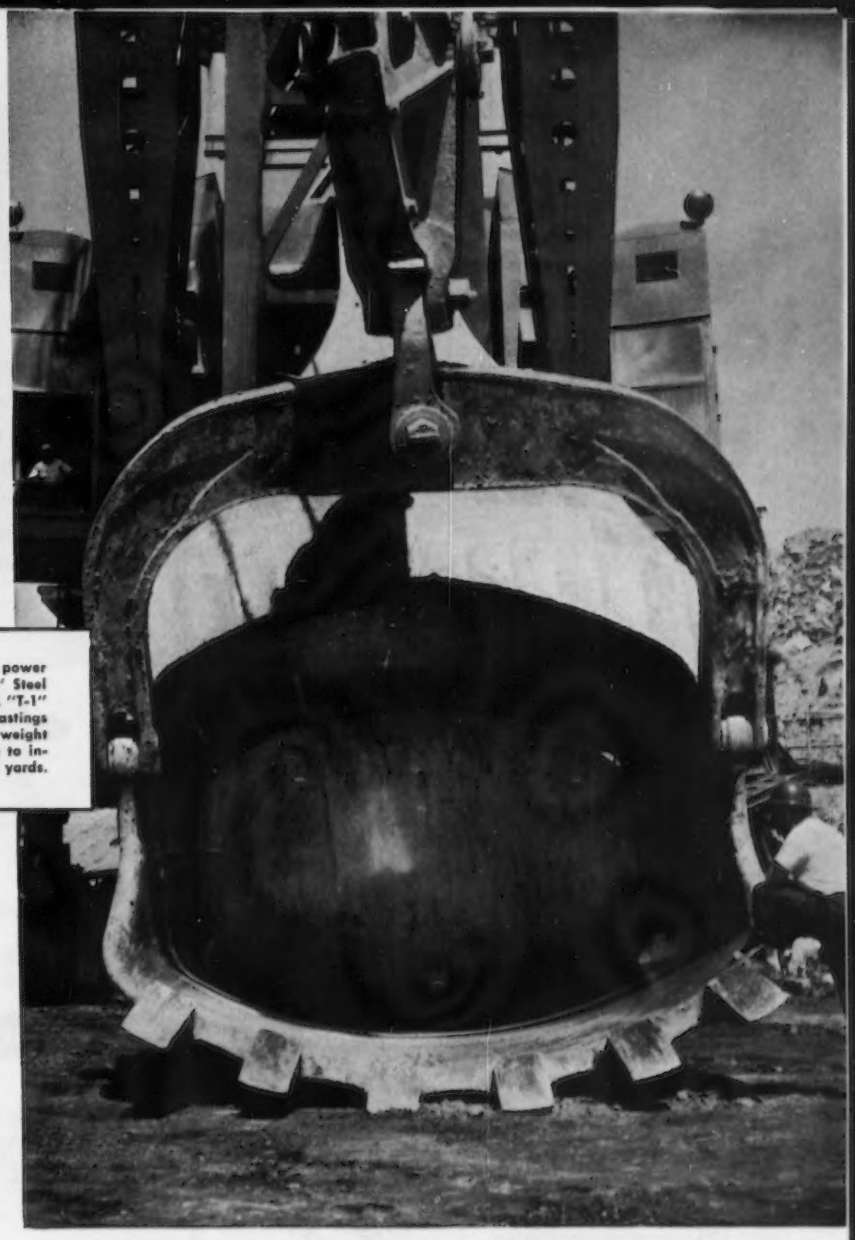

The entire shell of the bucket on this 50-cu. yd. power shovel is fabricated from ¾" and 6½" "T-1" Steel Plate. Liner plates are made of ½" "T-1" Steel. "T-1" Steel Plate only 6½" thick has replaced large castings a foot thick in the lip of the bucket. Lighter weight construction with "T-1" Steel made it possible to increase the cubic capacity of the bucket by ten yards.

How USS "T-1" STEEL in big machines

cuts weight, cuts cost, increases service life

Hanna Coal Company just can't afford to have this giant 50-cu. yd. shovel break down. This machine can move 2,280,000 tons of material a month, and it must operate continuously—24 hours a day, 7 days a week—to pay off.

Strong, weldable "T-1" Steel has improved the performance of this incredibly rugged machine, and it also has cut cost and weight. It enables the designers to use *fabricated* parts in place of larger, heavier, more expensive castings. And these lower-cost fabricated parts actually *last longer* than castings. As a result, Hanna Coal Company has standardized on "T-1" Steel for the vital parts of much of its heaviest-duty equipment.

Write for complete information on new USS "T-1" Steel. It has application in pressure vessels, rotating machinery, structural steel towers, steel mill equipment, big trucks, mine cars, and elsewhere.

Visit the U.S. Steel Booth
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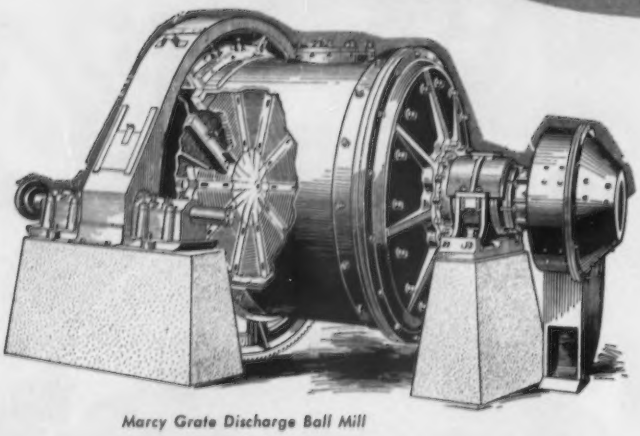
USS "T1" CONSTRUCTIONAL ALLOY STEEL

USS

S-475

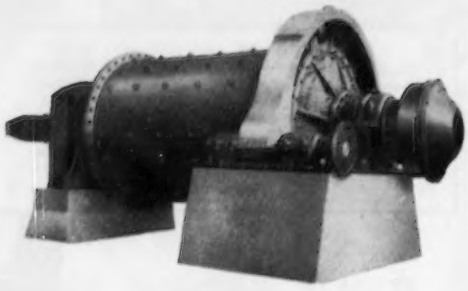
UNITED STATES STEEL

★ ★ ★ DIRECTORY of



Marcy Grate Discharge Ball Mill

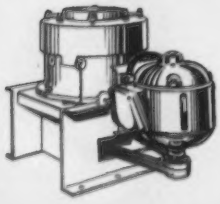
For Wet or Dry Grinding of ore, cement, clay or fibrous materials. Types, sizes and capacities for from 5 tons up to 3000 tons per 24 hours. Marcy Grate Discharge Ball Mills and Open End Rod Mills have unique features resulting in quick discharge, maximum useful grinding, minimum overgrinding and better metallurgy. Used throughout the world.



Marcy Open End Rod Mill

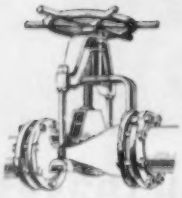
Massco Gy-roll Reduction Laboratory Crusher

Reduces ½" feed to as fine as 10 mesh in single pass. High capacity with low power consumption. 6" and 10" sizes.



Massco-Grigsby Rubber Pinch Valves

Designed for abrasive and corrosive pulps. Patented hinged sleeve for longer wear. 1" to 12" diameter. Up to 150 pounds continuous pressure.

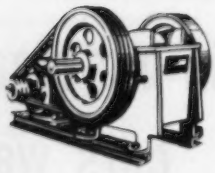


Massco-Adams Reagent Feeders

For wet reagents and other liquids. No mechanically driven moving parts. Only one micrometer screw adjustment. Siphon principle. Requires no electrical connections.

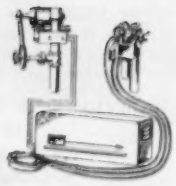
Massco Laboratory Jaw Crusher

Welded steel frame; manganese steel jaw and check plates; bronze bushed bearings; smooth jaws give better product and easier cleaning. Adjust for plate wear by convenient hand wheel adjustment.



Massco-Adams Density Controller

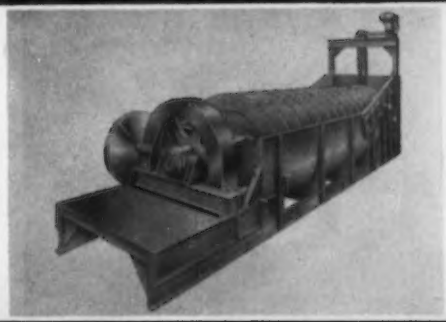
Automatically regulates water dilution of pulp in grinding circuit to maintain constant percent solids—thus, controls size of finished product.



cost-cutting equipment

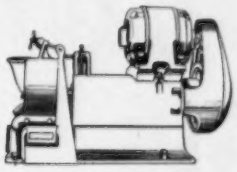
Akins Classifiers and HMS Separators

Akins Classifiers are made in sizes from 12" to 84" dia., simplex and duplex. They are used for classification of solids by size, dewatering, washing coal, preparation of china clay and glass sand, desliming and de-oiling phosphate rock, sink-float concentration. Used throughout the world by hundreds of the best companies in the mining and process industries.



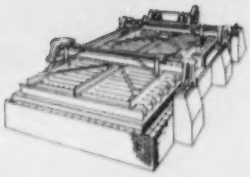
Massco-McCool Pulverizers

Disc type grinder with planetary movement. No gears. Will grind to 150 mesh in one pass.



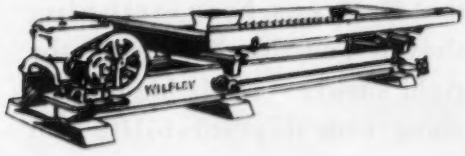
Lowden Dryer

For drying flotation concentrates, graphite, clays, ground minerals, paint fillers, pigments, various precipitates. Can use most any fuel including live steam and waste heat.



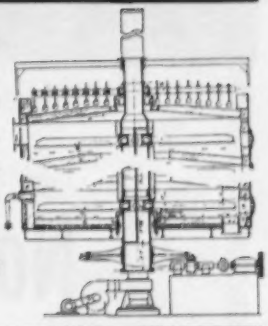
Wilfley Tables

For separation of any ore or material amenable to gravity concentration. Laboratory and commercial sizes—up to 180 tons capacity per 24 hours.



Skinner Roasters

For roasting and calcining ores, clays, limestone, limestone mud; decomposing oil sludge in process of producing sulphuric acid; incinerating sewage and garbage. Coal, oil or gas fired. Sizes to 22' inside diameter; up to 12 hearths.



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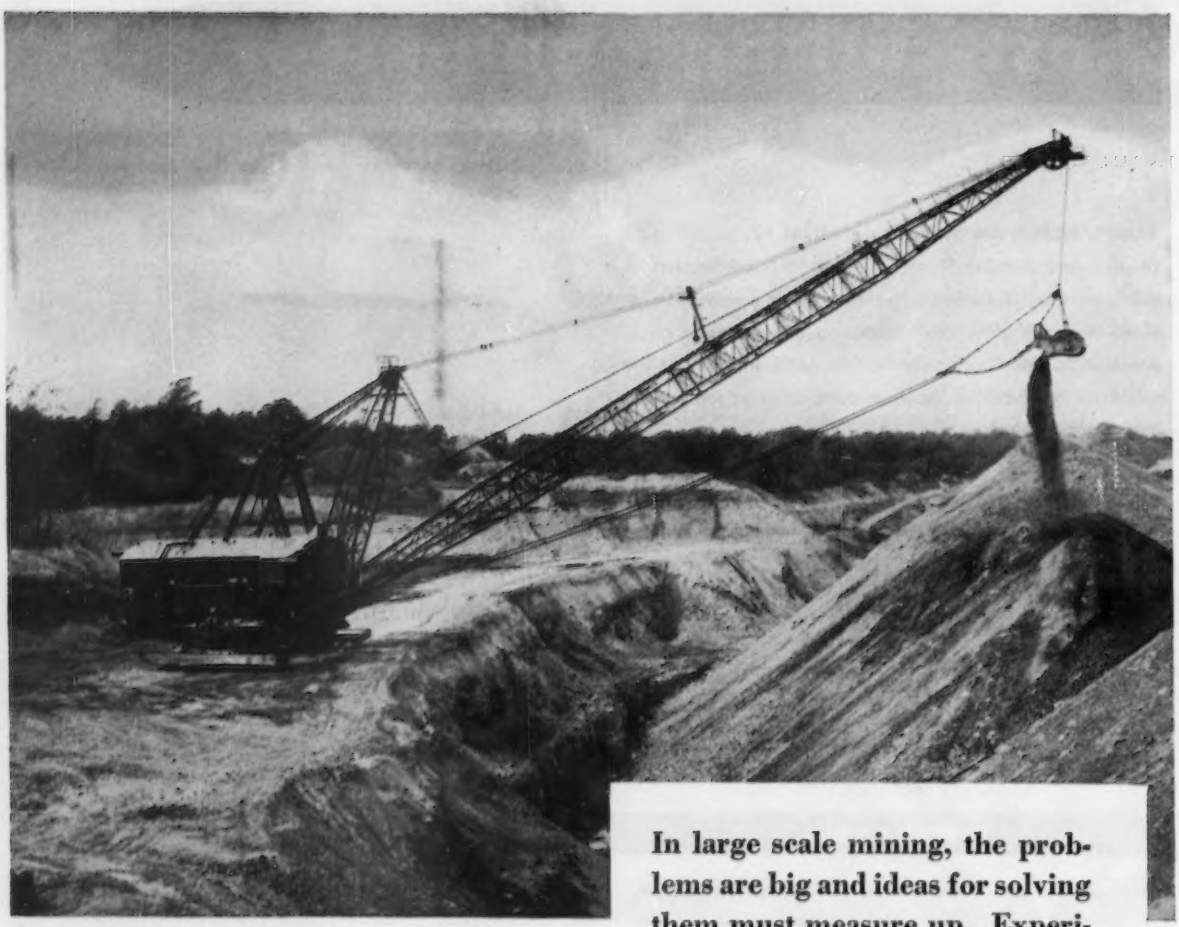


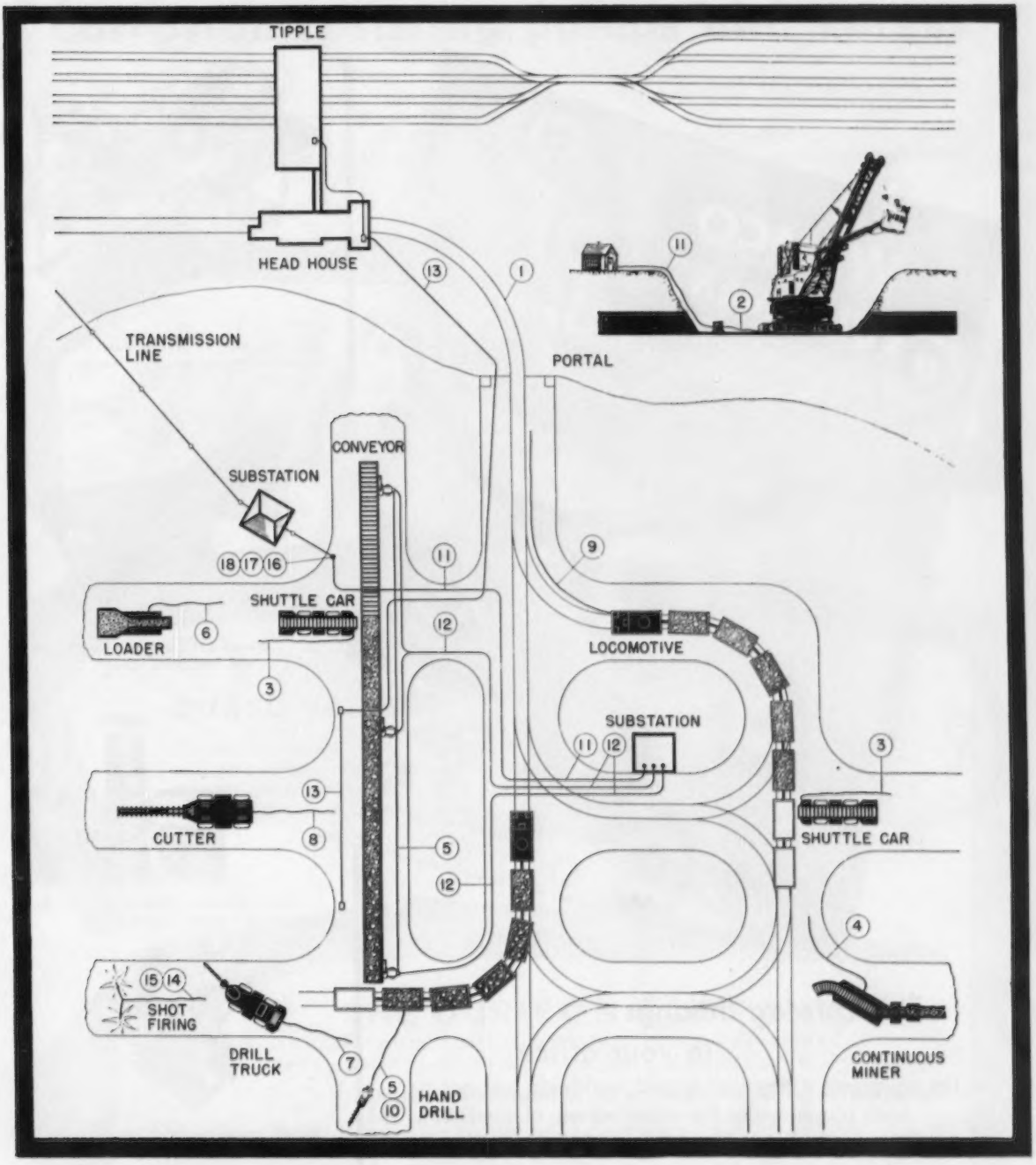
No place for little ideas...

In large scale mining, the problems are big and ideas for solving them must measure up. Experienced strip mine operators know that Bucyrus-Erie stripping shovels and draglines offer the right answer – really big output, along with dependability and economical operation. In addition they provide long working ranges, time-saving maneuverability, and the basic simplicity of design that means low maintenance costs.

If your mining operation requires the economical handling of big yardages, investigate Bucyrus-Erie stripping shovels and draglines. 17154

BUCYRUS ERIE

South Milwaukee, Wisconsin



Choose your mine cable from this page

It takes a miner to understand mine problems.

And at Anaconda we're miners ourselves—as well as the world's largest manufacturer of mine wire and cable.

From tipple to mine face there are Anaconda wires and cables—designed, made and tested by mine cable experts—for *every* job in the mechanized mine. These wires and cables have proved records of safety and economy in mines all over the world.

Ask your Anaconda Distributor for these Anaconda products:

1) Trolley wire; 2) Shovel cable; 3) Shuttle-car cable; 4) Continuous mining-machine cable; 5) Remote-control and heavy-duty drill cord; 6) Loader cable; 7) Drill-truck cable; 8) Mining-(cutting) machine cable; 9) Gathering-locomotive cable; 10) Hand-drill cord; 11) Mine-power cable; 12) Low-voltage power and feeder cable; 13) Telephone cable; 14) Shot-firing cord; 15) Blasting-cap wire; 16) Borehole and mineshaft cable; 17) Anaconda suspension unit for borehole cable; 18) Armored cable suspension unit.

For more information, call or write Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y. 34048

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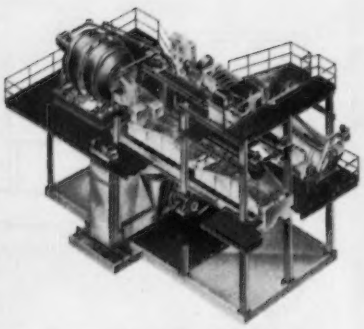
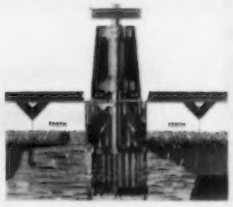


HMS Equipment — Wemco Mobil-Mills, Separatory Vessels, Densifiers, Medium Pumps and Thickeners

Wemco S-H Classifiers, Coal Spirals and Dewatering Spirals



Wemco Fagergren Flotation Machines for selective and rougher circuits

Wemco Torque-Flow Solids Pumps and Sand, Diaphragm and Vertical Pumps

ADDITIONAL EQUIPMENT AND SERVICES

- *Thickeners and Hydroseparators*
- *Conditioners and Agitators*
- *Attrition Machines*
- *Laboratory Units — Flotation, HMS, etc.*
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The equipment it describes is used worldwide and has been proven under the widest variety of conditions. Wemco equipment belongs in your operation. Here it is all described in one convenient reference.

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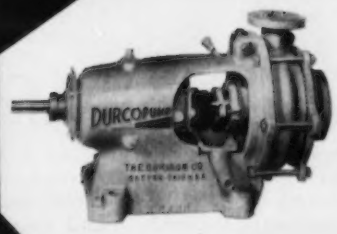
Corrosion resisting pumps and valves

For 43 years The Duriron Company has specialized in the manufacture of engineered equipment in a wide variety of special DURCO corrosion resisting alloys. Many, many Durcopumps and Durco Valves are now in service in the chemical industries under the most rugged conditions.

If you use pumps or valves in corrosive service, let us send you facts about these and other Durco products.



DURCOPUMPS

Standard and self-priming centrifugal pumps are available in stainless steel and other Durco alloys. Heads to 240 feet and capacities to 2000 G.P.M. Details in *free* Bulletin P/4.

DURCO VALVES

Durco stainless alloy Y valves, angle valves and plug valves are available in sizes to 10" for various corrosive applications. Details in *free* Bulletins in the V series.

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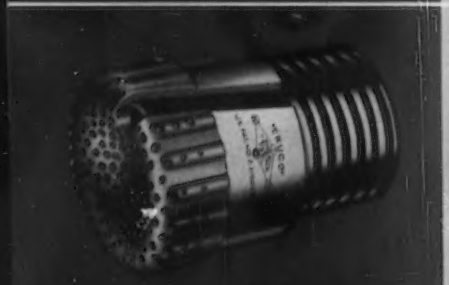
TRUCO DIAMOND DRILL BITS *by Wheel Trueing*

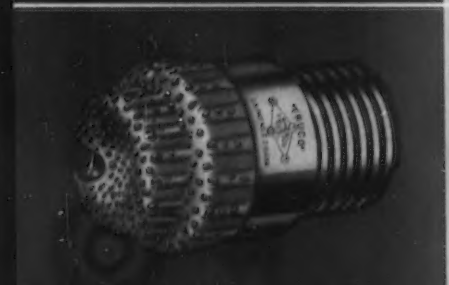
TRUCO CORING BITS

Maximum core recovery is normal performance for Truco Coring Bits in all formations. Diamonds are carefully selected, graded and set in a matrix of patented Truco Metal, famous for abrasive resistance and for its "welded" hold on diamonds to prevent loss. Truco Bits hold their gauge throughout their life and maintain proper clearance, thus enabling sludge and cuttings to move freely away from the face of the bit. Exceptionally fast and free cutting; high diamond recovery; very low footage costs. All standard sizes. State make and size of reaming shells or core barrel when ordering.



TRUCO CONCAVE BLAST HOLE BITS

Designed for use in all softer formations where cores are not required. Good for hard use in broken ground. Because the center of solid bits has no cutting speed, these bits are set with special quality center diamonds to take extra wear and prevent breakage. Water hole and groove are specially designed and positioned for maximum clearance of cuttings. Excellent performance in formations where only coring bits have previously worked. All standard sizes. State make and size of reaming shell or coupling when ordering.



TRUCO PILOT BITS

Another bit giving fine performance in formations previously considered suitable only for coring bits. Particularly adapted to variable rock formations where concave bits tend to "wander". Will not mud or ball up; cuts clean and true in soft and hard formations on all standard rigs. Very popular with engineers and drillers on long blast hole drilling and grouting work. The perfect teammate for Truco Concave Blast Hole Bits. All standard sizes. State make and size of reaming shell or coupling when ordering.

TRUCO IMPREGNATED CORE BITS

(no resetting required)

Drillers count on this Truco Bit for fast, economical footage under the roughest hole conditions. It stands up to abuse and keeps going where surface set bits might be affected by impact and abrasion from cherty, fractured and non-homogeneous formations. Fine, small diamonds, evenly distributed throughout the matrix give continuous high performance until all are used up*. Truco Impregnated Bits are set in "H" matrix and require sand-blasting during use. Bits may be run until the diamond bearing matrix is completely used. State make and size of reaming shell or core barrel when ordering.

**Available in four different series for ultimate performance in different formations.*

TRUCO CASING BITS AND SHOES

Ruggedly built and set with carefully selected diamonds properly placed in patented matrix to stand up to rough usage and insure low footage cost from surface to bed rock. Although conditions vary widely and, therefore, costs also, Truco Casing Bits will always prove notably economical. Truco Casing Shoes permit set bit and reaming shell to pass through. *Impregnated* Casing Bits and Casing Shoes are also available. All standard sizes. State make and size of your equipment when ordering Casing Bits or Shoes.

WHEEL TRUEING TOOL COMPANY

TRUCO DIAMOND DRILL BITS *by Wheel Trueing*

TRUCO REAMING SHELLS

Strip type—made to exact tolerances with strips placed in any desired positions. These shells ream accurately and hold gauge to the end of their life. Used with Truco Bits, they insure accurate hole size and eliminate subsequent reaming with bits. Can be run behind a solid bit to minimize vibration.

Ring type shells are preferred by many drillers in hard, broken formations. All sizes available. State make and size of core barrel when ordering.

STANDARD OIL FIELD BIT

In addition to all kinds of mining bits, Truco builds a complete range of oil field diamond drilling products including large bits 9" in diameter and over. The Standard Oil Field Bit, shown above, is for drilling in unknown structures varying from soft limestone and shale to hard, dense sandstone and chert. It is used throughout the oil fields and is also useful for drilling gas wells and water wells. It is a rugged and reliable general purpose bit with a wide range of applications.

When ordering Truco Oil Field Bits always state whether hard or standard matrix is desired; the diamond quality preferred; and the size and type of core barrel being used.

PROMPT and EXPERT RESETTING SERVICE

The promptness of our resetting service enables drillers to keep bits working steadily with little time lost in servicing. Bits are ready for use most of the time and not in the process of being reset. Therefore, fewer bits are needed and less money is tied up in bits.

Diamonds are salvaged from worn bits by an exclusive process which cannot damage them. New diamonds are added and set at critical points of wear. New diamond weight is approximately the same as the quantity lost or damaged in use, and reconditioning, therefore, is simply the cost of new diamonds and resetting.

The exceptional holding qualities of Truco Patented Matrix Metal insures good salvage from Truco Bits and every usable stone is reset to its best advantage.

Before resetting bits, wear and performance data are studied, and our engineers can often make small changes to improve performance in specific applications.

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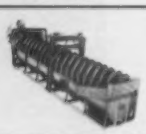
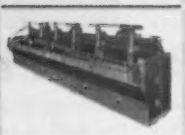
Write for illustrated catalog and price list of Truco Diamond Drilling Products

WHEEL TRUEING TOOL COMPANY

Complete DENVER MILL EQUIPMENT

		SIZES		WRITE FOR
DENVER (Patented) **SUPER AGITATORS & CONDITIONERS**		3' x 3' to 20' x 20'	Patented standpipe around propeller shaft assures positive agitation and circulation. Patented weir collar prevents sand-up on shut-down. Heavy-duty as well as acid-proof construction is available.	Bulletin No. A2-B4
DENVER Steel-Head **BALL MILLS**		3' x 2' to 6' x 12'	A Denver Steel-Head Ball Mill will suit your particular need. Five types of discharge trunnions. All-steel construction. Low initial cost due to quantity production. Quick delivery. Laboratory and pilot plant mills also available.	Bulletin No. B2-B13
DENVER Forced-Feed **JAW CRUSHER**		2¼" x 3½" to 32" x 40"	Cast steel frame, manganese jaw and cheek plates. Large diameter shafts reduce shaft deflection and thus increase life of heavy-duty, oversize roller bearings in bumper. Setting easily controlled.	Bulletin No. C12-B12
DENVER Spiral **CLASSIFIER**		6" Simplex to 60" Duplex	Has many improvements. For instance, lower bearing placed above pulp level, arrangement of feed, overflow and direction of rotation result in maximum efficiency. Rake-type and Denver-Finney classifiers also available.	Bulletin No. C5C-B
DENVER Selective **MINERAL JIG**		4" x 6" Simplex to 36" x 48" Duplex	An improved, pulsating, gravity selector that treats unclassified, unsized feed and recovers minerals as soon as freed. Easy to regulate and control, minimum attention. Use in closed grinding circuit or open circuit.	Bulletin No. J2-B10
DENVER Disc **FILTERS**		1 Disc, 2' to 8 Disc, 6'	Special, patented design of segments in Denver Disc Filters use both gravity and vacuum to give a drier filter cake. Drainage is complete and positive, with no blow-back. Simple, low-cost, dependable construction. Quick delivery. Also Drum and Pan Filters.	Bulletin No. F9-B2
DENVER "Sub-A" **FLOTATION**		16" x 16" to 56" x 56"	More large plants are installing Denver "Sub-A's" for their entire flotation job — roughing, scavenging, cleaning and re-cleaning — because they give maximum recovery at a low cost per ton. Dependable, low-cost, simplified continuous operation.	Bulletin No. F10-B81
DENVER SRL **SAND PUMPS**		Up to 2400 G.P.M.	Pressure-molded rubber parts, accurately engineered, give high efficiency at low horsepower. DECO also manufactures Denver Vertical Sand Pumps, and Adjustable Stroke Diaphragm Pumps.	Bulletin No. P9-B8
DENVER Automatic **SAMPLERS**		16" to 60" Cutter Travel	Extra rigid track and ball-bearing wheels assure positive travel and timing of sample cutter. Denver Vezin Type, Denver Snyder Type, or complete sampling systems available. Standard, low cost.	Bulletin No. S1-B4
DENVER Dillon **SCREENS**		1' x 3' to 6' x 14'	Gives fast, clean separation without blinding. Gives even, smooth flow of material because of the patented "true-circle" eccentric action. Two bearing construction saves 50% HP.	Bulletin No. S3-B11
DENVER Spiral Rake **THICKENER**		3' x 3' to 80' x 12'	Enclosed, running-in-oil head motion. Patented spiral rakes move settled solids to center discharge with continuous motion, rapid removal of solids tends to eliminate overload. Wood, Steel or rubber-covered Tanks available.	Bulletin No. T5-B5

OTHER ITEMS: Ore Testing, Mill Design, Pilot Plant and Laboratory Equipment, Jigs, Tables, Hydro Classifiers, Power Plants, Elevators, Conveyors, Reagent and Ore Feeders, Pulp Distributors, Dryers, Ore Cars, Tanks, Placer Equipment, Cyanide and Leaching Equipment.

DENVER EQUIPMENT COMPANY

1400 SEVENTEENTH STREET DENVER 17, COLORADO PHONE CHerry 4-4466

Planning an ore handling project?

Straight as an arrow, Link-Belt roller bearing belt conveyor rises from iron ore pit floor to concentrating plant. Almost one-third of a mile long, its uninterrupted delivery of high tonnages permits far lower handling costs than other forms of transportation.

LINK-BELT accepts complete responsibility for design, equipment, erection and performance

As mineral deposits grow leaner, larger and larger tonnages must be handled to recover concentrates in quantities to meet ever-increasing demands. At the same time, the processing of many ores has become more complex. These are two good reasons why it pays to call in Link-Belt if you're planning an ore handling project.

For Link-Belt will accept complete responsibility for the design, erection and furnishing of systems for handling ore and overburden—plus responsibility for satisfactory performance.

An installation—typical of many on which Link-Belt has performed this overall function—might move huge tonnages from the mine . . . process, store and reclaim the material . . . finally carry it to rail or dockside and load it out.

Get the facts on how this single *proved* source can integrate every factor of any contemplated project, large or small. A call to the Link-Belt office near you will place Link-Belt's broad engineering facilities at your disposal.

LINK-BELT

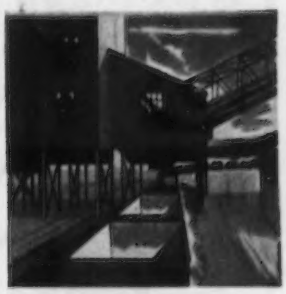
PROCESSING AND HANDLING EQUIPMENT 19.300

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

OVERALL ENGINEERING. Experienced design and field engineering staffs integrate all factors, assure expert planning.

DEPENDABLE EQUIPMENT. From Link-Belt's broad line, you get equipment that will stand up under the toughest jobs.

COMPLETE ERECTION. Experienced Link-Belt superintendents, staffs and skilled crews carry through on every detail.



SATISFACTORY PERFORMANCE. When you rely on Link-Belt as a source, we accept responsibility for successful operation.

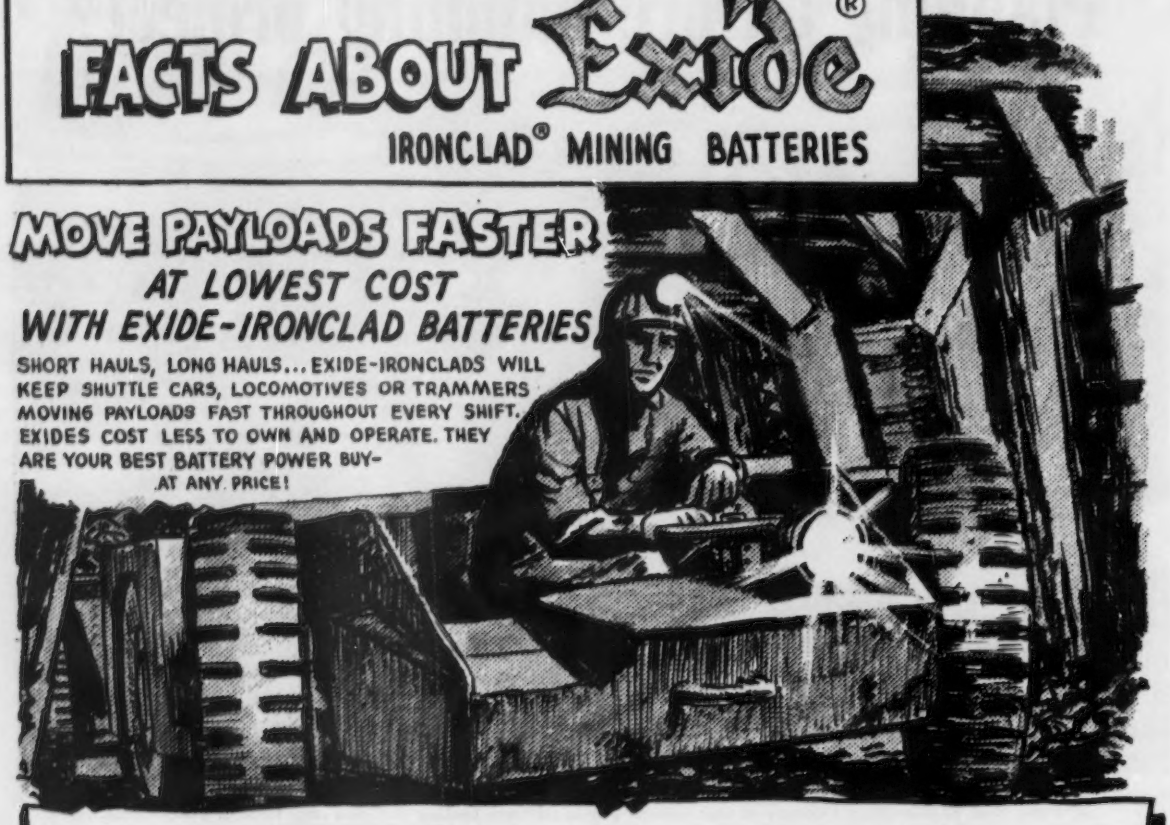
FACTS ABOUT Exide®

IRONCLAD® MINING BATTERIES

MOVE PAYLOADS FASTER

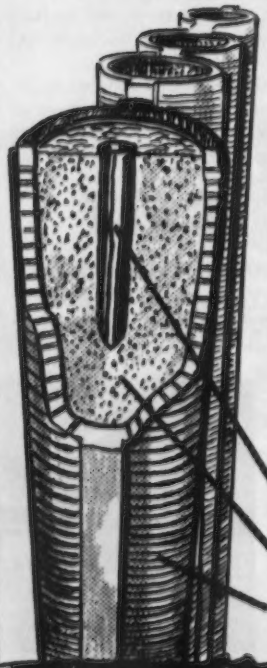
AT LOWEST COST WITH EXIDE-IRONCLAD BATTERIES

SHORT HAULS, LONG HAULS... EXIDE-IRONCLADS WILL KEEP SHUTTLE CARS, LOCOMOTIVES OR TRAMMERS MOVING PAYLOADS FAST THROUGHOUT EVERY SHIFT. EXIDES COST LESS TO OWN AND OPERATE. THEY ARE YOUR BEST BATTERY POWER BUY— AT ANY PRICE!



NATURE'S IDEAL SHAPE

THE CIRCLE WORKS FOR YOU INSIDE AN EXIDE-IRONCLAD



SLOTTED TUBES INSIDE AN IRONCLAD KEEP ACTIVE MATERIAL IN FIRM CONTACT WITH CONDUCTING GRIDS OF THE POSITIVE PLATE... THIS GRID PROTECTION LENGTHENS LIFE OF BATTERY. THE SLOTTED TUBES EXPOSE MORE ACTIVE MATERIAL TO THE ELECTROLYTE... FOR GREATER POWER. FINE TUBE SLOTS HOLD MATERIAL IN CONTACT WITH GRID LONGER... RESULT, THE IRONCLAD'S ABILITY TO DO YOUR MINE HAULAGE JOB FOR A LONGER PERIOD OF TIME. THAT IS WHY

EXIDE-IRONCLADS

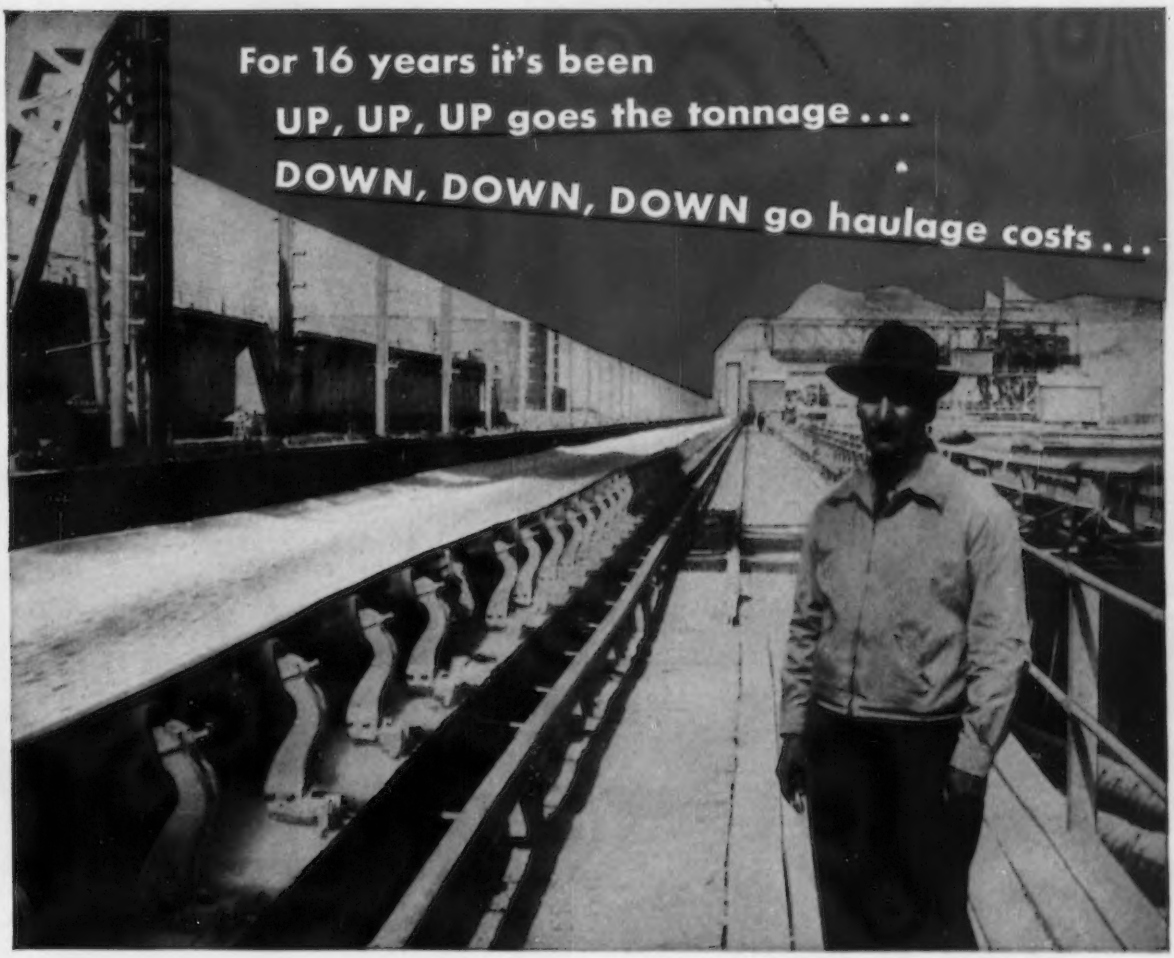
ARE YOUR BEST MINING BATTERY BUY—

AT ANY PRICE!

IRONCLAD POSITIVE PLATE

LET EXIDE HELP SOLVE YOUR MINING BATTERY PROBLEMS. ❶ CALL AN EXIDE SALES ENGINEER FOR FULL DETAILS. ❷ WRITE FOR FORM 1982, A MANUAL ON MAINTAINING MOTIVE POWER BATTERIES.

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.



35¢ per 1000 tons hauled—with this record-breaking "U. S." Belt

This belt was a record-breaker back in 1951. At that time it had completed conveying the amazing total of 100,000,000 tons of abrasive copper ore, and was in its twelfth year of service.

Installed in 1939, it has now been in continuous operation under rugged conditions for sixteen years. *Working 12 months a year, this belt continues to add to its record. Total tonnage to date: over 131,000,000 tons.*

Not only does this belt resist the extreme abrasive action of copper ore that would shorten the life of an ordinary belt—it is completely unhoused all year 'round and exposed to the direct rays of the sun—highly destructive to ordinary rubber.

Such success as this results from 3-way engineering teamwork; mine operators, designers of conveyor equipment, and United States Rubber Company belt engineers. This teamwork results in long, trouble-free service that has made "U. S." belts the most widely-used throughout the mining industry. You can obtain these quality belts and engineering service through any of the 27 "U. S." District Sales Offices.

"U.S." Research perfects it . . . "U.S." Production builds it . . . U.S. Industry depends on it.

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

Asbestos mine moves 4000 tons daily on 8 trucks

The Johnson's Company, Ltd., with headquarters at Thetford Mines, Quebec, has been mining and processing asbestos ore in this region for close to 70 years.

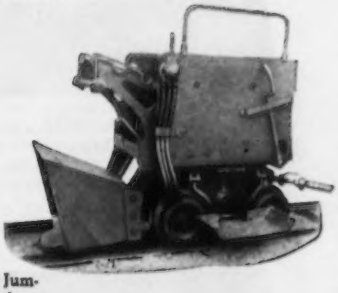
Its newest mill and open-pit mine at nearby Black Lake represents an $8,000,000 development and the last word in modern equipment. Typical of its efficient methods is the daily movement of 4000 tons of asbestos ore on 8 big Mack dump trucks over a ¾-mile haul from the mine to the primary crusher.

To keep its ore moving on uninterrupted schedule, The Johnson's Company decided their best investment was Mack. They accordingly purchased the 8 Model LV, diesel-powered Mack trucks of 22½ tons capacity. Actual performance of these trucks, each carrying 500 tons daily, has more than confirmed the wisdom of the company's choice.

MACK TRUCKS Empire State Building, New York 1, N. Y.

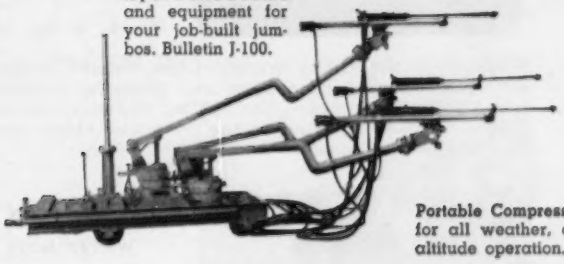
Low-cost development and production with engineered deep hole percussion drilling equipment. Deep Hole Drills, Ring Seal Shank, Long-Feed Mountings, Sectional Rods and Couplings. Bulletin DHPD-1.

Compact and efficient air compressors.



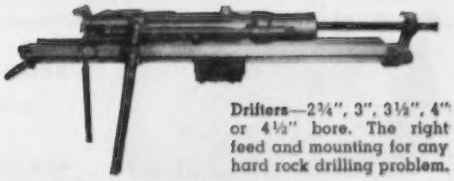
Mine Car Loaders — fast, powerful, safe.

Hydraulic Drill Jumbos. *Tractor Jumbos.* Hydraulic Booms and equipment for your job-built jumbos. Bulletin J-100.



Stopers — direct or telescopic - direct feed leg. Two sizes: 2¾" and 3⅛".

Sinkers—hand-held or feed-leg mounted. The right combination for every rock.



Drifters—2¾", 3", 3½", 4" or 4½" bore. The right feed and mounting for any hard rock drilling problem.

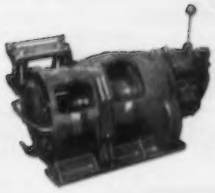
Portable Compressors for all weather, any altitude operation.

Increase Your Mining Profit with help from Gardner-Denver

Drill Steel Sharpeners. Low-cost steel forming.

A Sump Pump that won't bury itself in mud.

Duplex Power Pumps for mine de-watering and water supply. Grout Pumps, air or steam operated.



High torque Airslushers and Air Hoists.

Write for descriptive information.

SINCE 1859

GARDNER-DENVER

THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada) Ltd., 14 Curity Avenue, Toronto 16, Ontario

GOODALL RUBBER COMPANY

EST. 1870

GENERAL OFFICES, MILLS and EXPORT DIVISION: 430 WHITEHEAD ROAD, TRENTON 4, N. J.

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ST. PAUL • LOS ANGELES • SAN FRANCISCO • SEATTLE • SPOKANE • PORTLAND • SALT LAKE CITY • DENVER
HOUSTON • STUART, FLA.

Goodall Rubber Company of Canada, Ltd., Toronto — *Distributors in Other Principal Cities.*

"MINE KING"
AIR HOSE

Sizes ½" to 1", I.D.

A Goodall "Standard of Quality" product, designed especially for mining service. Molded and braided construction, with extra strong duck carcass, oilproof tube and tough, wear-resistant cover that protects carcass from penetration of sulphurous mine water. Extremely flexible. Double and triple cord. Continuous lengths up to 500 feet.

"BROWN CORD"
AIR HOSE

Sizes ½" to 1", I.D.

A molded-and-braided hose for drilling, riveting, and other general pneumatic tool service. Tube, carcass and cover are combined to assure great strength and durability, without impairing flexibility and easy handling. Oilproof tube; rubber cover. Available in lengths up to 500 feet.

"SUBWAY" ®
AIR HOSE

Sizes ½" to 1¼", I.D.

Another Goodall "Standard of Quality" hose especially built for rock drilling and all other heavy-duty air tool work. Light weight, flexible, easy to handle. Tough, oilproof black rubber tube; highest quality wrapped duck carcass; wear- and weather-resistant red rubber cover. Maximum lengths of 50 feet.

"HARDROK" ®
WIRE BRAID AIR HOSE

A super-hose for rock drills in construction, quarrying, mining and any other heavy-duty air service. Longwearing, oilproof Synplastic tube; horizontally braided steel wire carcass; tough yellow rubber cover, with black spiral stripe for identification. Light in weight, extremely flexible. Sizes ½" to 2", inclusive; two and three braid.

"NEWTYPE"
SUCTION AND DISCHARGE

Patented wire-reinforced, woven cord construction gives "Newtype" unusual strength and durability for both suction and discharge. Light weight, extremely flexible. Cannot kink, buckle or collapse, yet if accidentally crushed, can be quickly rounded into shape again without harm. Smooth bore. Sizes 1" to 4", I.D. Max. lengths of 50 feet.

"INFERNO" ®
STEAM HOSE

Sizes ½" to 2½", I.D.

Built with multiple layer wire braid carcass, heat-resistant tube and tough, abrasive-resistant red rubber cover. Wire braids will cause steam to be diffused from damaged hose, providing a safety factor against sudden burst. Extremely flexible. Recommended for pressure up to 200 lbs., and temperatures up to 400°F. Maximum lengths of 50 feet.

"76"
STEAM HOSE

Sizes ½" to 2½", I.D.

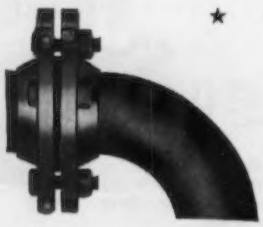
Combines all the quality characteristics required for long, safe performance under conditions involving pressures over 100 lbs., but not exceeding 150 lbs. Wrapped duck construction, with high-temperature tube and black wear-resistant cover. Maximum lengths of 50 feet.

"BUCKSKIN"
WATER HOSE

Sizes ½" to 4", I.D.

Long famous for quality and reliability in every water hose service. Tube is of slow-aging rubber stock—tough and pliable. Strong rubber cover withstands roughest surface wear and abuse, and affords maximum protection to cotton duck carcass from contact with moisture. Maximum lengths of 50 feet.

★ ★ ★



"KEMITE" DUCT WITH "FLANG-LOK"
Floating Flanges

For mine suction and discharge. Tube offers highest resistance to abrasive wear. Wire-reinforced carcass will not kink or collapse. Cover is tough, long-wearing rubber compound. Generally furnished with "Flang-Lok" Ends, to accommodate "Flang-Lok" Flanges. Sizes up to 4", I.D.

"FLANG-LOK" FLANGES provide the most convenient and efficient method of connecting "Kemite" Duct, effecting a leakproof, rubber-to-rubber seal, and permitting full flow. For bolt alignment, flanges turn independently of the duct or pipe. No gaskets or washers. All sizes.

"GOODITE" FLEXIBLE PIPE. Same construction and advantages as "Kemite" Duct, above, but available in larger sizes—up to 12", I.D.

The GOODALL Trademark on hose, belting, boots and clothing for the Mining Industry represents a standard of quality and reliability established through eighty-five years of manufacturing experience, backed by continuing research and development. Product specifications are based on first-hand knowledge of mine service requirements, with selected materials, expert craftsmanship and careful inspection assuring the utmost in on-the-job performance and economy.

GOODALL RUBBER COMPANY

EST. 1870

CONVEYOR BELTING

"SUPER TRIPLE-S." Goodall's finest grade. Heavy duck carcass, high tensile rubber covers and strong friction between plies. Designed to carry run-o-mine coal, ores, slag and crushed limestone up to 10", wet or dry. Widths up to 48".

"TRIPLE-S." Same superior quality as "Super Triple-S," but of somewhat lighter construction. Widths up to 48".

"GOODALL." The *right* belt for the great number of lighter conveying jobs where the *extra* qualities of "Super Triple-S" and "Triple-S" are not required. For sized coal, crushed stone, gravel, shells, ashes, etc. Widths up to 48".

ELEVATOR BELTING

"SUPER TRIPLE-S," "TRIPLE-S" and "LA CROSSE" are long-established Goodall brands, built to specifications that assure reliable, economical service under conditions for which each is designed. "La Crosse" made in widths up to 30", others to 48". Available with extra features—punching, stitching, endless—if desired.

"POWER KING" TRANSMISSION BELTING

Friction surface, raw edge construction, especially built for most severe service. Minimum stretch and firm contact with pulleys at high speeds. Highest quality skim friction between plies. 35 oz. silver duck.

★ ★ ★

Other Goodall Products for the Mining Industry

PUMP DIAPHRAGMS	RUBBER SHEET PACKING
PUMP VALVES	RUBBER & DUCK PACKING
PISTON PACKING	CHUTE LINING
ASBESTOS PACKING	HOSE COUPLINGS, CLAMPS

LIQUID CORROSION-RESISTANT LININGS

GOODALL WATERPROOF FOOTWEAR and CLOTHING

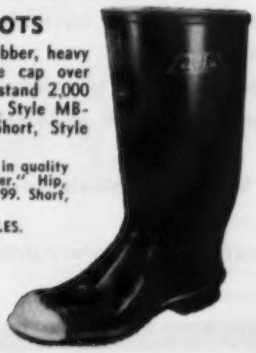
Famous for Quality, Comfort and Long Wear

"TOE-SAVER" ® BOOTS

Smooth, tough, flexible jet black rubber, heavy duck lined. Cushion insole. White cap over reinforced steel toe tested to withstand 2,000 lbs. pressure. Tire-tread soles. Hip, Style MB-346. Storm King, Style MB780. Short, Style MB946.

"WEAR KING" ® BOOTS—Identical in quality with above, but without "Toe-Saver." Hip, Style MB345. Storm King, Style MB799. Short, Style MB945.

"RUBBERHIDE" SAFETY INNERSOLES. Sheet of high-tensile spring steel bonded between layer of top grade sole leather and layer of rubberized canvas duck. Puncture-proof.



MINER'S PACS Top quality black rubber Lace Pacs, Style ML-975, 16" high; Style ML-760, 15" high. Cushion insole. Cleated outsole. "Toe-Saver" Safety Toe. Also non-lace "Terra Haute" pacs, Style ML-271, in otherwise same construction. Other boots, workshoes, arctics and rubbers, built for extra wear and comfort.

COATS, JACKETS, OVERALLS

Items too numerous to describe here, in rubber, oiled and latex . . . all designed to afford maximum protection plus comfort in every kind of work. Style 338 coat is a long-time favorite . . . double back; corduroy-lined collar; length 49".

SAFETY HATS

"Hardboiled" Safety Hats in fibre glass and aluminum. Easiest to wear, yet providing maximum protection. Also, miners' caps, with or without lamp brackets.

TUNNEL SUITS

Style 80 jacket with Style 81 Overall makes the ideal suit for underground work. Other suit combinations to meet every preference or need.

★ ★ ★

Write for catalog describing the complete Goodall clothing and footwear line.

Proved

THE OUTSTANDING PORTABLE ROTARY DRILL FOR EXPLORATION, CORING, SAMPLING

MODEL 1000 COMBINATION
FOR DRILLING WITH
WATER OR AIR

Highly mobile, rugged, and versatile the MAYHEW model 1000 Rig has proved, under every operating condition, to be outstanding in both performance and over-all cost.

All necessary power units, air compressor, slush pump, and equipment are an integral part of this truck mounted drill. Compressor and pump work from the transfer case through separate clutches. Through this MAYHEW-ENGINEERED feature greater operational savings are effected. The drill can be quickly switched to use either AIR or WATER as drilling conditions change.

As optional equipment a MAYHEW-BUILT Dust Sampler is available — designed to meet the highest requirements.

Write, wire, or phone MAYHEW, manufacturers of portable rotary drilling equipment for over 30 years.

Home Office	**MAYHEW SUPPLY CO., INC.** 4700 SCYENE ROAD, DALLAS, TEXAS
Branches	LUBBOCK, TEXAS; TULSA, OKLAHOMA; CASPER, WYOMING; SIDNEY, MONTANA; GRAND JUNCTION, COLORADO EXPLORATION EQUIPMENT CO., INC., HOUSTON, TEXAS
Canada	SEISMIC SERVICE SUPPLY, LTD., CALGARY, ALTA.
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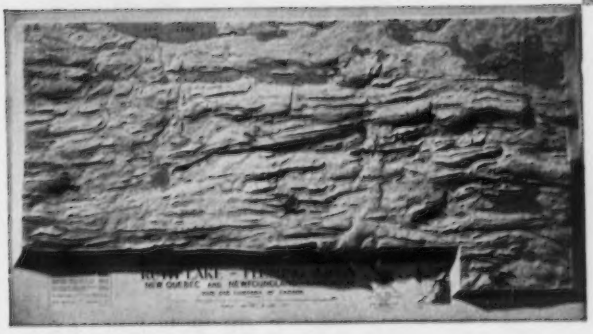
Important mineral finds are being uncovered by Aero clients with the airborne magnetometer

Precise aerial mosiacs provide valuable reconnaissance and planning data

Accurate Aero topographic maps aid engineering development



Light weight, plastic relief models give Aero maps a 3rd dimension for management

AERO's modern mining tools are cutting exploration and mapping costs . . . helping to locate new deposits of magnetite, ilmenite, nickel and asbestos . . . and putting schedules months and even years ahead. AERO maps are delivered speedily, and are so accurate, mining engineers are using them for plotting boreholes, property lines, rail spurs, access roads, power lines, and other phases of planning and development. Call on 36 years' experience of AERO—pioneer and leader in aerial surveys.

AERO SERVICE CORPORATION
PHILADELPHIA 20, PA.
Oldest Flying Corporation in the World

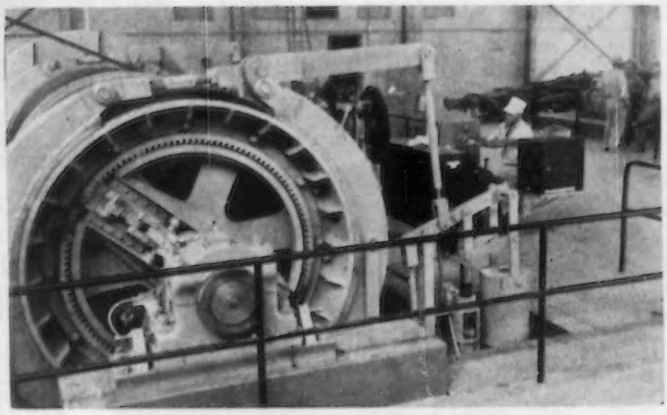
TAKE IT UP WITH STEARNS-ROGER

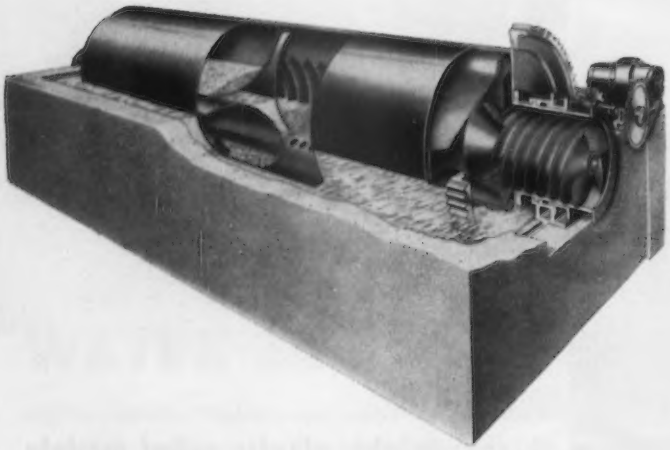
...for specialized equipment of improved design to assure greater efficiency

MINE HOISTS:

Typical of hoists designed and manufactured by us for specific requirements is this twin drum, 22,000 lb. electric hoist. Each drum is cast Meehanite* . . . 84″ dia, 78″ face, winding 1,200 feet of 1⅛″ cable. For any size, type, or design . . . put your hoisting problems in experienced hands.

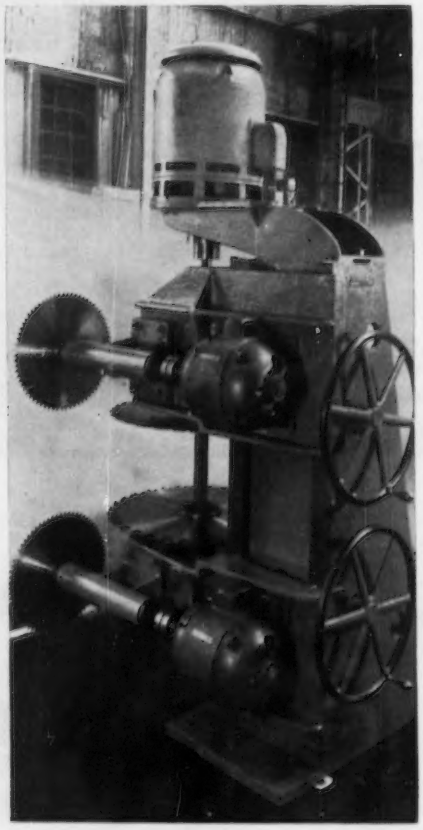
*Trade Mark Registered.





TIMBER FRAMERS:

Stearns-Roger framers cut tenons true-to-line and "out of wind" whether log is straight or crooked, round or square. Single end framer cuts complete tenon in 2 quick passes for each end . . . 3″ thick and up, 1″ to 10″ long, and from 3′ to 8′ between shoulders.



CALCINE COOLER:

Stearns-Roger Improved Calcine Cooler has internal cells which approximately double the cooling surface and uses the economy of water cooling both by conduction and evaporation. Water level is regulated so cooler and load virtually float—reducing friction and power needs. Special flights or lifters advance hot material through the proper length of cooler to obtain desired temperature.

Stearns-Roger

THE STEARNS-ROGER MFG. CO. DENVER, COLORADO

Sprague & Henwood's ORIENTED Diamond Bits Cut Faster— —Last Longer Cost No More

The MOST ECONOMICAL DIAMOND BITS Ever Produced

AFTER extensive comparative tests, conducted in cooperation with the U. S. Bureau of Mines, had proved that drill diamonds cut much faster and last much longer when "oriented" in the matrix with their hardest edges or "vectors" toward the work we decided that random setting was obsolete. Since then we have standardized on oriented diamond bits and have produced **thousands**—in a wide variety of types and sizes, with both cast- and powdered-metal matrices — to meet every diamond drilling requirement.

In terms of footage costs, we believe these to be the most economical diamond bits ever produced, and invite inquiries on that basis. Bulletin 320 illustrates all types and gives complete working data. Write for a free copy and tell us about your drilling conditions. Our experienced executives welcome opportunities to make money-saving suggestions.

HIGH-SPEED DIAMOND-DRILLING MACHINES

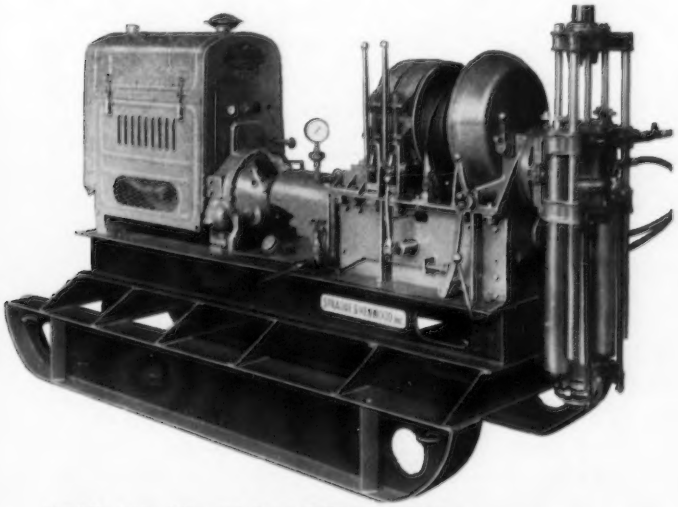
To secure best possible results from our Oriented diamond bits, you need drilling machines with plenty of power and a wide range of both speed and feed. Sprague & Henwood machines not only meet these requirements but, in addition, can be relied upon for many years of dependable trouble-free service. Modern designs, rugged construction and alloy-steel wearing parts permit long periods of continuous high-speed operation under normal conditions.

Write us regarding any requirement for a diamond drilling machine. Our recommendations are based on actual results obtained in our own world-wide contract drilling operations. Illustrated bulletins mailed promptly on request.

Model 325 with Pneumatic Rod Puller

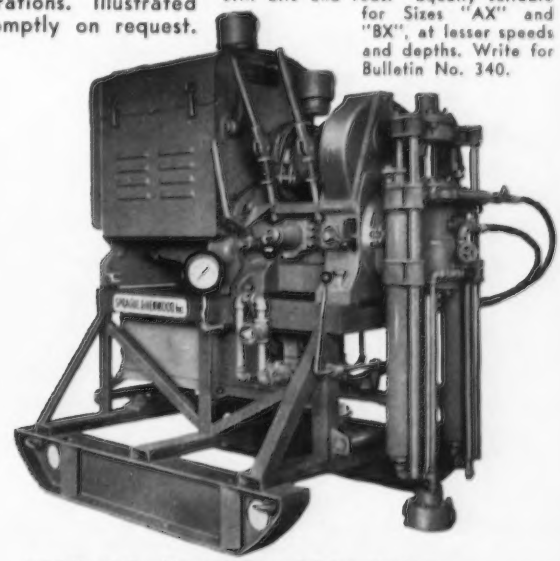
Air Operated Machines for Diamond Drilling Underground

Model 325, shown above, and Model 550 (similar but larger) are both driven by four-cylinder radial-type air motors and have ample capacity for fast steady operation of Size "EX" drill bits and rods. Equally suitable for Sizes "AX" and "BX", at lesser speeds and depths. Write for Bulletin No. 340.



MODEL 142 Diamond Core Drilling Machine
For Deep, or Large-Diameter, Core Drilling Jobs

Built "Like a Battle Ship" for tough service and capable of bringing out good cores at far greater depths than its rated capacity, when especially equipped for deep drilling. Rated Capacity—"EX"—2000′; "AX"—1650′; "BX"—1200′; "NX"—1000′. Write for Bulletin No. 160.



MODEL 40-C Diamond Core Drilling Machine
The Best Machine for Most Core Drilling Jobs

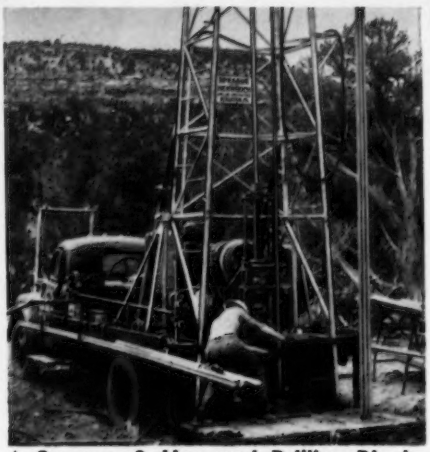
Designed for greatest possible all-round value and performance on jobs up to a thousand feet in depth, no matter how difficult the operating conditions. Rated Capacity—"EX"—1000′; "AX"—800′; "BX"—600′; "NX"—500′. Write for Bulletin No. 185.

SEE OTHER SIDE OF THIS PAGE FOR FURTHER SPRAGUE & HENWOOD INFORMATION

CONTRACT DIAMOND DRILLING
Anywhere *Any Time*

FOR more than seventy years Sprague & Henwood, Inc. has been a leader in the field of Contract Diamond Drilling. During this long period of time our crews have completed thousands of contracts successfully in every corner of the globe—under every conceivable operating condition. Today we have a large force of expert operators and an ample supply of modern equipment, so that we can undertake almost any job—anywhere—on short notice.

Besides exploratory core drilling, from the surface or underground, our service includes blast-hole drilling, directional drilling, foundation test drilling, grout-hole drilling and pressure grouting. Estimates, and constructive suggestions when possible, submitted promptly on request.



A Sprague & Henwood Drilling Rig in the Colorado Uranium Field.

ACCESSORY EQUIPMENT
for Diamond Core Drilling and Soil Sampling

In order to meet the requirements of our own contract drilling crews, we are obliged to supply a wide variety of accessory equipment and to carry all of the more important items in stock for immediate shipment. The same prompt service is available to other diamond drill operators and ordering is made easy by a 28-page catalog, No. 31-F, which gives all necessary information, including illustrations, piece numbers, weights, and code words for convenience when ordering by wire or cable. Every operator of a diamond drilling rig should have a copy of Bulletin No. 31-F and we'll send one free of charge on request.

Soil Sampling Devices and Equipment are illustrated and cataloged in our Bulletin No. 75-A (20 pages) which also contains helpful information regarding approved methods of recovering samples for Soil Investigation and Foundation Testing. Write for a free copy if you can use it.

COMPLETE DRILLING RIGS

On receipt of adequate information regarding the anticipated operating conditions and requirements, we will furnish a complete list of all necessary equipment for successful diamond core drilling and will quote on delivery of equipment anywhere in the United States or in any other country. Long experience in furnishing equipment for our own drilling crews enables us to include items that are often overlooked but which are indispensable under certain conditions—especially for deep core drilling.

Partial List of Accessory Equipment Available

- Auger Bits, all types
- Bails, lifting
- Ball-Bearing Waterswivels
- Bits, Diamond
- Bits, Blank
- Bits, Chopping
- Bushings, Rod & Casing
- Casings, Flush Coupled
- Casing Taps
- Clinometers
- Corebarrels, all types
- Corebarrel Taps
- Core Lifters
- Couplings, Rod
- Derrick Sheaves
- Drill Rods
- Drive Hammers
- Drive Heads
- Drive Pipe
- Drive Pipe Couplings
- Drive Shoes
- Extensions, Core Barrel
- Fishing Tools
- Fishtail Bits
- Flush Coupled Casing
- Foot Safety Clamp
- Hoisting Hooks
- Hoisting Plugs
- Hoisting Plug Reducers
- Hoisting Rings
- Hose, Waterswivel
- Hose, Suction
- Jar Lengths
- Jaws, Safety Clamp
- Lifters, Rod
- Mud Bits
- Pilot Reamers
- Plugs, Hoisting
- Pressure Testers
- Protectors, Casing
- Reamer Shells
- Reducers, Rod
- Rods, Drill
- Rod Couplings
- Rod Taps
- Rose Bits
- Safety Clamps
- Sawtooth Bits
- Sheave Wheels
- Soil Samplers
- Subs
- Taps, Fishing
- Testers, Sample
- Testers, Pressure
- Wash Plugs
- Water Swivels

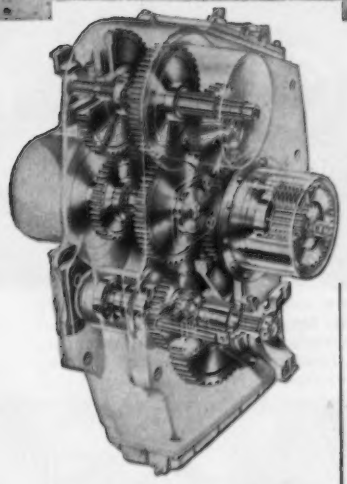
SPRAGUE & HENWOOD, Inc. • SCRANTON 2, PA.

BRANCH OFFICES:

NEW YORK • PHILA. • PITTSBURGH • GRAND JUNCTION, COL. • BUCHANS, NEWFOUNDLAND

EXPORT REPRESENTATIVE: PHILIPS EXPORT CO., 100 EAST 42nd St., NEW YORK 17, N. Y.

One-Yard capacity MICHIGAN Tractor Shovel feeds conveyor at Climax Uranium Co.



Here's the secret of
BIG TIME-SAVINGS:

the MICHIGAN Power-Shift Transmission! Forward-Reverse and High-Low gears are in constant mesh. Shifting is accomplished by hydraulic pressure. The power-shift levers on the steering column actuate control valves in the transmission. These valves direct oil pressure to the multiple disc-clutches, transmit engine power from the selected drive gears to the output shaft. Hydraulic oil completely lubricates all drive gears and bearings as it flows from top to bottom and returns to the sump through a fine-mesh screen.

You'll cut your loading time!

with the MICHIGAN Power-Shift Transmission

Operating a MICHIGAN Tractor Shovel is both fast and easy. Gone is the old-fashioned heavy duty foot clutch; gone is the tiresome work of clutching every time you shift gears.

The MICHIGAN Power-Shift Transmission does all the work for you. All you do is operate the finger-tip hand levers on the steering column . . . one for Forward-Reverse, the other for High-Low speed. Make either shift *while moving in either direction without coming to a stop.*

The MICHIGAN'S power-shift transmission speeds up operation, cuts loading time, gets you TOP YARDAGE per day.

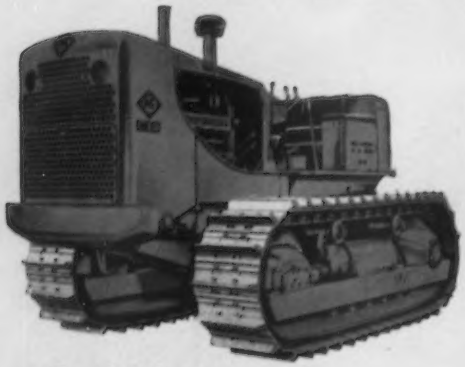
Get a demonstration right on your own job. It is easily arranged: just phone your MICHIGAN distributor. Did you know MICHIGAN Tractor Shovels are available under the Clark Leasing Plan? We would be glad to send you full details.

CLARK EQUIPMENT

CLARK EQUIPMENT COMPANY
Construction Machinery Division
436 Second St., Benton Harbor 25, Michigan

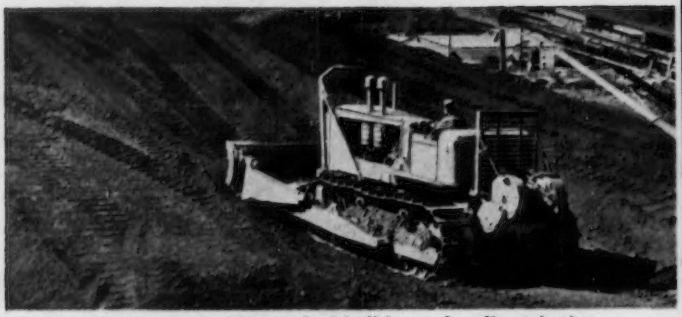
MODERN ALLIS-CHALMERS EQUIPMENT

Surface Mining

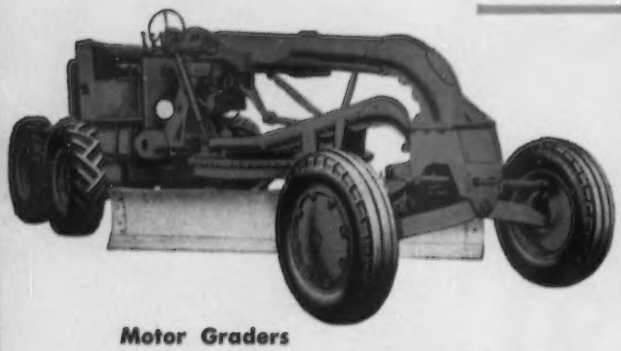


Crawler Tractors

HD-21 (Largest of 4 Allis-Chalmers models)
Torque Converter Drive
204 net engine hp, 44,000 lb



Crawler tractors with matched bulldozers handle stripping, stockpiling and many other jobs. Allis-Chalmers exclusive box-A main frame does not transmit strain from dozer to engine, clutch or transmission — just one of many proven features that give long life.



Motor Graders

Three diesel-powered models up to 23,000 lb
One gasoline engine model
50 hp, 8,800 lb

Motor graders combine power and minute precision as they level pit bottoms or prepare dragline sites. Adjustable seat, power steering and pilot house visibility of this AD-40 help the operator work better with less effort.

Motor Scrapers

TS-360 (shown) 20-yd capacity, heaped
TS-200 13-cu-yd capacity, heaped
Also 5 pull-type scrapers
Capacities from 2 to 18 cu yd

For big-volume stripping, you can count on Allis-Chalmers Motor Scrapers to load fast, travel fast and dump clean. Special, high-apron lift prevents material from jamming. Even when loaded from overhead, anything that can be put into the bowl can be easily ejected.

Motor Wagons

Rear- and bottom-dump models
Bodies interchangeable with Motor Scraper bodies

Large top area of this Allis-Chalmers bottom-dump Motor Wagon permits fast loading with less spillage. Positive hydraulic steering lets operator spot wagon quickly without tiring wheel fight. Hydraulically operated doors allow full or controlled dumping.

SERVING THE MINING INDUSTRY

Hauling and Haul Roads

Allis-Chalmers crawler tractors and pull-type scrapers are an ideal team for tough cut and fill work and short-haul stripping. Whether pushing or pulling, Allis-Chalmers torque converter drive sets new standards of tractor-scraper performance.

The low-cost Model D is a real economy leader on haul road maintenance jobs. It has tandem drive, ROLL-AWAY moldboard, tubular frame and other big-grader features, yet it costs only one-third that of large machines.

The TS-200 Motor Scraper develops 17 hp per cu yd struck capacity. This gives you high travel speed when it counts most — traveling with a payload or working on adverse grades. Positive, controlled hydraulic steering permits fast, safe travel.

Wheel base on the TR-200 Motor Wagon does not change while dumping. Thus, operator can lock air brakes on all four wheels, while dumping over steep drops — an important safety advantage. Smooth interior, plus high, 70° tilt assures fast, clean dumping.

Underground Mining

The 1¼-yd HD-5G excavates ore, transports it to the surface, or loads shuttle cars underground. Tractor Shovels are available for all four Allis-Chalmers tractors with buckets up to 4 cu yd. All have electric starting on diesel fuel for greater safety.

KEEPING STEP WITH STEPPED-UP DEMANDS

In the past 15 or 20 years, the mining industry has kept production costs down in spite of rising labor and material costs. To do it, mine operators have pioneered new methods that put constantly increasing demands on machinery.

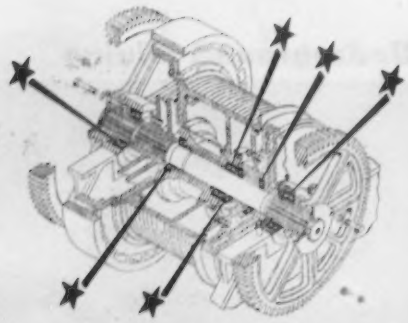
Through the years, Allis-Chalmers has kept pace with these conditions by gearing its equipment development to the mine operator's needs. Here is just a small sample of this modern equipment at work. For further information write Allis-Chalmers — producer of the most complete line of major mining tools.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

ROLL-AWAY is an Allis-Chalmers trademark.

LIMA'S

shafts and drums roll on anti-friction bearings



STARS INDICATE LOCATION OF ANTI-FRICTION BEARINGS IN DRUMS AND PILLOW BLOCKS

As a result of twenty-five years' experience with anti-friction bearings, Lima design engineers know exactly where to put them to give you maximum benefits. This cut away view shows how Lima utilizes anti-friction bearings in the drums. X-ray vision would show you how Lima uses them throughout the main machinery on all shafts and other important parts.

This modern means of eliminating destructive friction benefits LIMA owners through faster operating speeds and lower upkeep. Anti-friction bearings also maintain perfect shaft alignment and insures smoother, easier clutch action.

LIMA Type 2400 Shovel, equipped with 36' boom, 27' dipper handle, 6 cu. yd. dipper.

COMPARE! No other machine gives you as much as LIMA!

1. Bronze bushings in tread, idler and drive rollers are protected by piston-type dirt seal rings and retainers.
2. All gears, smaller parts and shafts which are subject to extra wear are flame or induction hardened for longer life.
3. Main machinery is placed well back of center of rotation to eliminate excess counterweight.
4. Anti-friction bearings, used at all important bearing points, reduce destructive friction, fuel consumption and lubrication requirements.
5. Big capacity drums and sheaves lengthen cable life by reducing the need for double wrapping and sharp bends in cable.
6. Full air controls on travel, hoist, swing and boom hoist, result in smoother, more precise operation, minimum maintenance and less operator fatigue.
7. Torque converter (optional) automatically adjusts speed to load requirements, minimizing shock loading, making performance smoother and faster.
8. Wherever you are, you can depend on skilled service and nearby warehouse stocks of parts to keep your LIMA on the job continuously.

COMPARE and you'll specify LIMA for shovels (¾ yd. to 6 yds.), cranes (to 110 tons) and draglines (variable). Smaller capacities available on rubber.

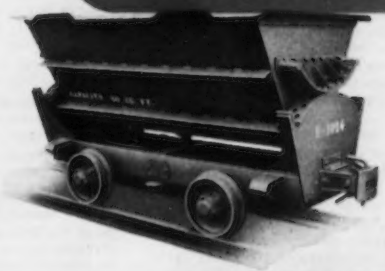
DISTRIBUTORS IN PRINCIPAL CITIES OF THE WORLD

LIMA

SHOVELS • CRANES
DRAGLINES • PULLSHOVELS

BALDWIN-LIMA-HAMILTON CORPORATION
Construction Equipment Division
LIMA, OHIO, U.S.A.

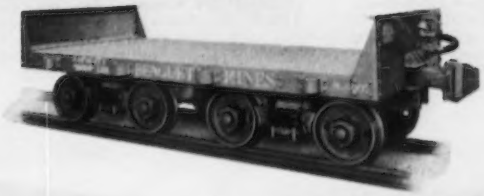
SKILL, KNOWLEDGE, and WORLD-WIDE EXPERIENCE Solve Your Transportation Problems and Needs



Manufacture of Mine Cars for Export Our Specialty

HIGHEST QUALITY RUGGED CONSTRUCTION

MODERN DESIGN PROMPT DELIVERY



We design and build mine cars to meet customer's particular requirements, or to suit standard railway specifications of countries served.

GREGG

THE GREGG COMPANY, LTD., 19 Rector St., New York 6, N.Y.
Cable Address: "GREGGCAR"

CYANAMID REAGENTS FOR METALLURGICAL USE

CYANIDATION-FLOTATION CHEMICALS

AERO® Brand Cyanide — Standard in all mining districts for the cyanidation of gold and silver ores. Used in flotation for the selective depression of sulfides of zinc, iron, copper, antimony and nickel; has also aided in the control of quartz and other silicates in non-metallic flotation operations.

Sodium Cyanide — Used in the cyanidation of gold and silver ores and as a selective depressant for various sulfides in flotation.

FLOTATION REAGENTS

AEROFLOAT® 15 and 25 Promoters — These liquid AEROFLOAT Promoters have combined promoting and frothing properties. AEROFLOAT 25 is the stronger promoter and has less frothing power than AEROFLOAT 15. Both are selective, effective promoters for silver, copper, lead and zinc sulfides, and will not actively promote iron sulfides in alkaline circuit. Are also valuable as promoter-frothers for gold flotation.

AEROFLOAT 31 and 33 Promoters — These liquid AEROFLOAT Promoters are similar in physical characteristics to AEROFLOAT 25, but are stronger promoters due to the presence of added fortifying agents. AEROFLOAT 31 is recommended for flotation of oxidized gold ores, sulfide copper ores and silver sulfides. It is also used as an auxiliary frother in non-metallic flotation operations. AEROFLOAT 33 Promoter is slightly stronger than AEROFLOAT 31, and is most widely used in the flotation of galena. AEROFLOAT 33 also is an excellent promoter for metallic gold and copper, and copper sulfides.

SODIUM AEROFLOAT® Promoter, AEROFLOAT 211 Promoter — These dry AEROFLOAT Promoters are water-soluble, and widely used as sphalerite promoters. Also used in flotation of gold, silver and copper sulfide minerals in presence of pyrite which they do not actively promote. Non-frothing promoters, they are generally used with a standard frother such as: AEROFROTH® 65, 70, 77 or 80 Frother, or in conjunction with a liquid AEROFLOAT Promoter which also possesses frothing properties.

AEROFLOAT 203, 213, and 226 Promoters — These dry, water-soluble AEROFLOAT Promoters are strong collectors for gold, silver, zinc and copper ores, and are somewhat more powerful than SODIUM AEROFLOAT Promoter. AEROFLOAT 213 and 226 Promoters exhibit some tendency to froth. Like other members of the dry AEROFLOAT group, they do not float pyrite readily in alkaline circuits. Are especially good zinc promoters, but not generally used for galena flotation.

AEROFLOAT 208 and 238 Promoters — These dry, non-frothing promoters are generally used with standard frothers, and are excellent promoters for copper, silver and zinc sulfides, and free gold. AEROFLOAT 208 Promoter is one of the strongest collectors developed for metallics and is widely used in the flotation of fine, free gold, native silver, and copper. It is the preferred collector for the flotation of chalcocite, bornite, covellite and secondary copper minerals. AEROFLOAT 238 Promoter is widely used in the flotation of copper sulfides and complex oxidized ores, and is preferred for the flotation of chalcopyrite.

AEROFLOAT 241 and 242 Promoters — These liquid AEROFLOAT Promoters are neutralized, water-soluble forms of AEROFLOAT 25 and 31 Promoters, respectively. Due to their water-solubility, they are more readily reactive in flotation and are, therefore, especially suited where a fast-acting promoter is essential, and little or no conditioning is possible. AEROFLOAT 242 is a slightly stronger promoter than AEROFLOAT 241. AEROFLOAT 242 is very often used together with AERO® Promoter 404 for the flotation of gold ores.

AEROFLOAT 243 Promoter — This dry AEROFLOAT Promoter resembles AEROFLOAT 203, but is slightly stronger in promoting action. It is particularly suitable for the flotation of gold, silver, copper and zinc ores.

AEROFLOAT 249 Promoter — This dry, water-soluble AEROFLOAT Promoter is used in the copper flotation plants of Northern Michigan. It is a stronger promoter than the other dry AEROFLOAT Promoters and also exhibits a tendency to produce more froth.

AERO® Xanthate 301 — Sodium secondary butyl xanthate is a powerful, water-soluble, non-frothing promoter for sulfide minerals, effective for use in bulk flotation of all types of sulfide ores and for oxidized base-metal ores after sulfidization. It is widely used for the flotation of pyritic gold ores in combination with AEROFLOAT 208 Promoter. It is often used with AEROFLOAT 15, as a very effective promoter-frother combination.

AERO Xanthate 303 — Potassium ethyl xanthate is a general purpose non-selective sulfide promoter that has slightly less promoting power than the corresponding sodium salt, and substantially less than the higher-alcohol xanthates.

AERO Xanthate 325 — A water-soluble, sodium ethyl xanthate reagent widely used as a sulfide promoter, alone or in conjunction with one of the liquid or dry AEROFLOAT Promoters. Its promoting strength, pound for pound, is somewhat greater than potassium ethyl xanthate, and somewhat less that of AERO Xanthates 301, 343, 350 and 360.

AERO Xanthate 343 — This sodium isopropyl xanthate is a strong promoter for all sulfide minerals. Promoting strength is between AERO Xanthate 325 and 301, and it is recommended for use where AERO Xanthate 325 provides insufficient promoting power.

AERO Xanthate 350 — This is an amyl xanthate, one of the most powerful xanthates available. It is particularly useful for flotation of oxidized lead and copper ores after sulfidization, and in operations where a powerful, non-selective sulfide promoter is desired.

AERO Xanthate 360 — This is a branch-chain amyl xanthate which exhibits slightly less promoting power than the straight-chain AERO Xanthate 350.

AERO® Promoter 404 — This dry solid is a powerful, water-soluble promoter that also exhibits some frother properties. It has found wide application in the flotation of oxidized lead and copper ores after sulfidization, and is often used as a secondary promoter together with xanthates and the AEROFLOAT Promoters, particularly in the flotation of copper and zinc sulfide ores. In some instances this reagent is effective in floating oxidized lead minerals without prior sulfidization.

SEPARATION PROCESSES BY GRAVITY DIFFERENCES

Cyanamid offers the two most advanced and efficient mechanical processes for minerals beneficiation and coal cleaning. Both processes employ unique, exclusive principles to achieve accurate separation at low cost.

To beneficiate metallic and non-metallic ores down to 10 mesh: HEAVY-MEDIA SEPARATION PROCESSES in which the force of gravity alone is used to make a sharp separation of the heavy and light constituents of the feed in a recoverable medium having a controlled specific gravity between that of the heavy and light fractions.

For treating ores ⅜" x 65 mesh: DUTCH STATE MINES CYCLONE SEPARATOR PROCESSES in which centrifugal-centripetal forces make a sharp separation between the heavy and light constituents in an exogenous or autogenous medium of predetermined specific gravity.

AERO Promoter 444 — This dry, water-soluble promoter is useful in the flotation of slow-floating lead, and copper and zinc sulfides, and for the flotation of oxidized lead and copper ores after sulfidization.

AERO* Thiocarbanilide 130 — An improved, readily-dispersible form of thiocarbanilide (diphenyl thiourea) that is useful in the flotation of base-metal sulfide ores, particularly those containing galena, as a supplementary promoter in conjunction with the AEROFLOAT Promoters and xanthates.

AEROFROTH® 63 Frother — This higher-alcohol type frother has found wide acceptance in the coal industry as a replacement for pine oil. It has a frothing-promoting action on such easy-to-float minerals as coal, graphite, sulfur, molybdenite and talc. Produces a more brittle, less persistent froth than pine oil or cresylic acid, with resultant improvement in selectivity on many ores.

AEROFROTH 65 Frother — This is a new synthetic, water-soluble frother which produces a closely-knit, selective froth. Mill results indicate greatly reduced frother consumptions with this material, of the order of 1/3 to 1/10 of previous consumption of certain other frothers. It produces a less brittle froth than the other AEROFROTH Frothers.

AEROFROTH 70 Frother — A branch-chain higher alcohol producing a more selective and less persistent froth than pine oil or cresylic acid. It is widely used in both metallic and non-metallic flotation operations.

AEROFROTH 77 Frother — This straight-chain higher alcohol has been substituted for pine oil and cresylic acid at many operations, with resulting increase in selectivity and reduction in frother consumption. Produces a slightly more persistent froth than AEROFROTH 70.

AEROFROTH 80 Frother — Latest addition to our alcohol frothers, this straight-chain, non-promoting frother produces a light-textured froth with high selectivity.

Cresylic Acid and Pine Oil — These tried and true frothers, standards after many years of usage in flotation operations, are available through Cyanamid.

AERO* Depressant 610 — This dry, water-soluble solid is a powerful depressant for talc, sericite and other gangue slimes, and also functions as a dispersing agent. Use at a number of zinc flotation plants has resulted in markedly lower insoluble and higher zinc contents of zinc flotation concentrates.

AERO Depressant 615 — A water-soluble dry powder that is useful as a depressant for talc, sericite and certain foliated ferromagnesian silicate minerals. Often used in conjunction with AERO Depressant 620.

AERO Depressant 620 — This water-soluble powder finds wide use as a depressant for talcose-schist gangue.

AERO Depressant 633 — Often used together with AERO Depressant 610, as well as alone, for talc depression, this water-soluble powder is also quite effective for depression of carbonaceous gangue.

AERO Depressant 645 — This material also finds wide use as a depressant for carbonaceous gangue. It is a water-soluble, dry powder.

AERO* Modifiers 158 and 162 — These water-soluble dry solids are effective in controlling deleterious gangue slimes in both metallic and non-metallic flotation operations. Their use often reduces reagent consumption and improves concentrate grade and recovery.

AERO* Promoter 708 — This crude tall oil fatty acid is widely used for the flotation of non-metallic ores. Provides efficient fatty acid promotion at low cost.

AERO Promoter 710 — This is the sodium soap of AERO Promoter 708. A water-soluble, easy-to-feed acid promoter for many non-metallic minerals.

AERO Promoter 712 — A water-soluble, saponified fatty acid promoter-frother, very useful in non-metallic and certain sulfide flotation operations.

AERO Promoters 721, 723, and 730 — These refined tall oil fatty acids contain both oleic and linoleic acids and are useful in non-metallic flotation where a crude fatty acid is not suitable. Average rosin acid content of these three reagents is 1%, 3½% and 30%, respectively.

AEROMINE® 2026 Promoter — This cationic promoter, product of Cyanamid research, was first used at Cyanamid's Florida phosphate operations as a silica promoter. Water-soluble, it also exhibits frothing properties.

AERO* Promoter 801 — Originally developed for the treatment of iron-oxide ores, this water-soluble petroleum sulfonate promoter finds wide use for the flotation of iron-bearing impurities from glass sands and ceramic raw materials such as feldspar.

AERO Promoters 824 and 825 — These oil-soluble petroleum sulfonate promoters are generally used in conjunction with AERO Promoter 801 for treatment of glass sands; also used for flotation of such non-metallics as rhodochrosite, kyanite, chromite and barite. They are dispersible in water with vigorous agitation.

AERO Promoter 827 — This reagent is similar to AERO Promoters 824 and 825, but is slightly more readily dispersible in water.

Yellow Prussiate of Soda (Sodium Ferrocyanide) — This water-soluble dry solid is finding wide use as a copper depressant in the separation of copper and molybdenum sulfides by froth flotation. (See U. S. Patent 2,664,199).

FLOCCULATING AGENTS

AEROFLOC® 548 and 552 Reagents — These two general purpose flocculants are in use at a variety of metallurgical operations for increasing thickening and filtration rates, and recovering solids formerly lost in thickener overflows. Useful in C.C.D. cyanidation plants. Most generally used in slurries with neutral or alkaline pH.

AEROFLOC 3000 Reagent—A recently-introduced AEROFLOC Reagent which is useful as both a thickening and filtration aid on a wide variety of solid suspensions. It is useful in highly-acid as well as in alkaline pulps.

OTHER METALLURGICAL CHEMICALS

Also available to the mining industry through Cyanamid are such chemicals as soda ash, copper sulfate, sodium silicate, alkali polyphosphates, zinc sulfate, oleic acid and others. We invite your inquiry for specific chemicals.

* AERO is a trade-mark of American Cyanamid Company applied to flotation reagents such as xanthates, promoters, modifiers, depressants, etc.

Have you received these Mineral Dressing Publications?

Cyanamid has available the following issues of its "Mineral Dressing Notes" series. We will be glad to send you a copy of issues which you may not have received:

No. 17 "Chemistry of Cyanidation".
No. 18 "Heavy-Media Separation Processes for Coal Preparation".
No. 19 "Heavy-Media Separation Processes for Mineral Concentration".
No. 20 "Cyanamid Reagents".
No. 21 "Froth Flotation".

In addition to the aforementioned publications, you may be interested in brochures on the beneficiation of these metallic ores and minerals which are also available:

Antimony	**Chromite**	**Cobalt**
Fluorspar	**Manganese**	**Molybdenum**
Sulfur	**Tin**	**Tungsten**

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FOR EASY HANDLING ON TOUGH JOBS . . .

and get "More Use per Dollar"

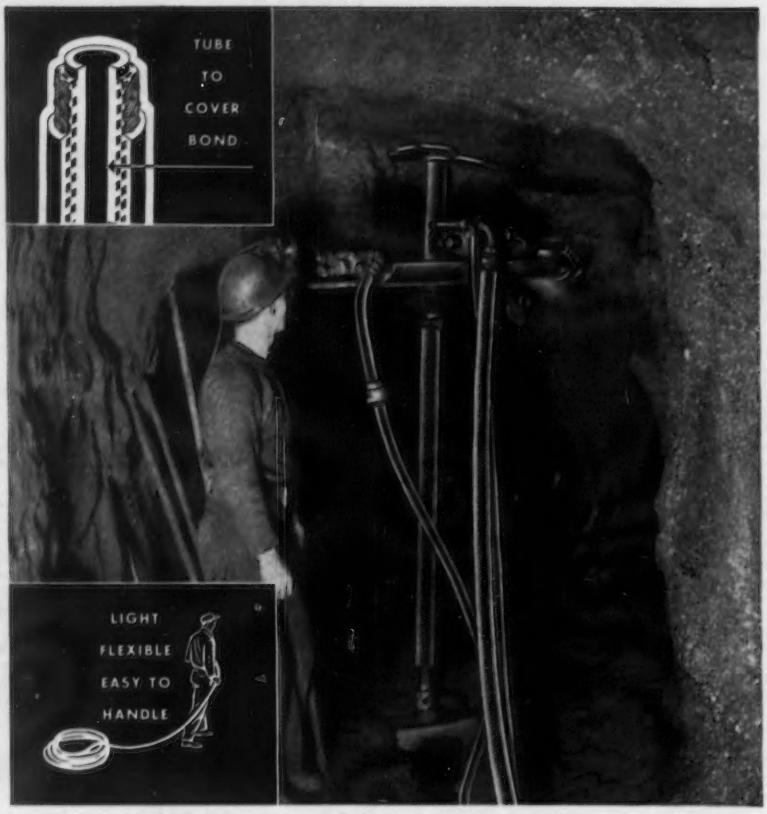
Select a light weight hose construction that is flexible and kink resistant for long-life dependability.

Hose that is light in weight—yet strong enough to safely withstand high pressures—is easier to handle. Men like it better and do more work with it. Look for a hose that is light, yet strong, for ease of handling.

If the hose you buy resists kinking you are assured maximum flow under all operating conditions. Hose that is mandrel-made, rather than molded in a pre-set coil, will coil and uncoil freely in any direction . . . eliminate points of strain at kinking points that can cause costly internal damage and rupture.

Make certain the hose is engineered for maximum flexibility . . . from tube to cover. Tube-to-cover flexibility prevents separation of cover, tube or strength member plies . . . reduces hose costs by increasing hose life.

Specify the one hose that gives you all these features . . . specify R/M Homoflex Hose.



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The unique construction of Homoflex Hose makes it easier to handle because it is light, has no pre-set twist . . . coils and uncoils easily without kinking. All unneeded bulk has been engineered out. An exclusive process creates a homogeneous cover, strength member and tube that are virtually inseparable to produce a hose construction that is extremely flexible, yet rugged and strong. Homoflex Hose does a better job under tough conditions . . . and it lasts longer. Inside and outside diameters are uniform.

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JALLOY HEAT-TREATED STEEL PLATE BEATS WEAR DUE TO IMPACT AND ABRASION

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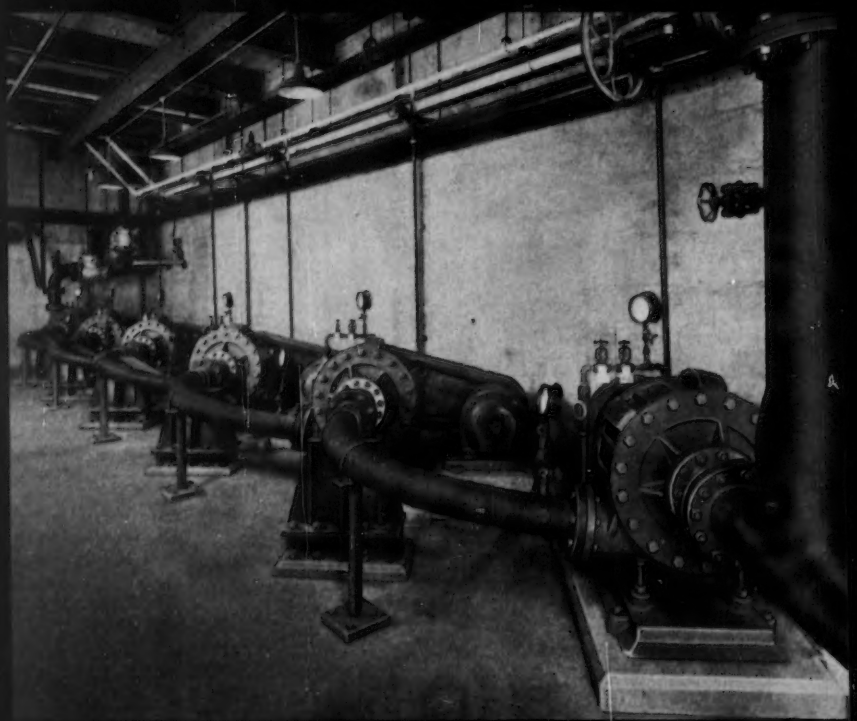

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A new order calls for six in series—at more than twice the capacity of those shown in the photo at right.

Installations such as these have proven to hundreds of wise "HAZLETON" users that the best pump gives the lowest long run cost.

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Balanced thrust—No stuffing box—Patented
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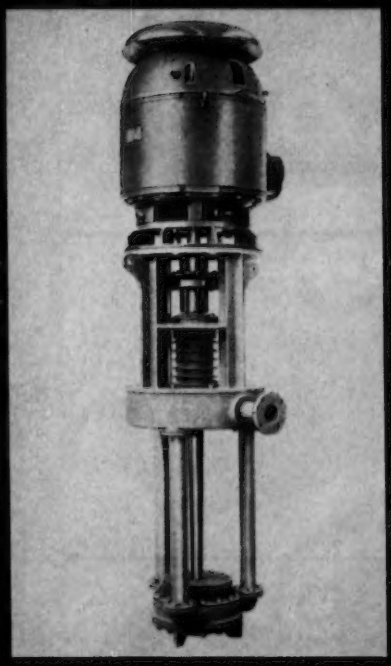

"HAZLETON'S" latest—A truly portable shaft sinking pump. No bottom bearing—No stuffing box. Completely weatherproof. 75 HP—500' head. (Smaller units available.)

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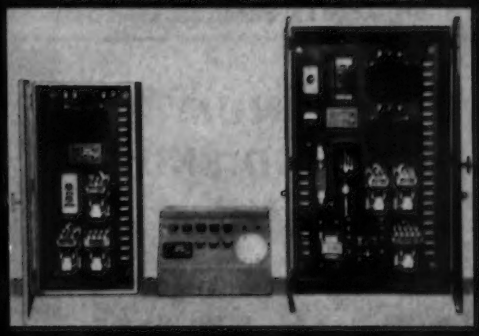

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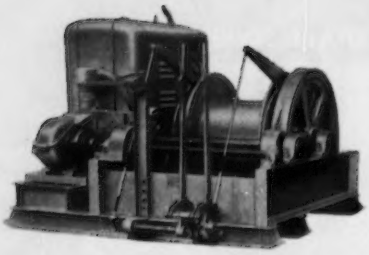
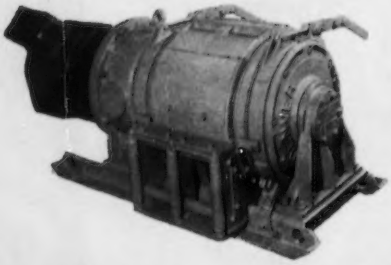
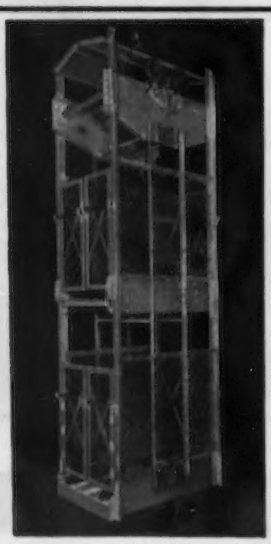
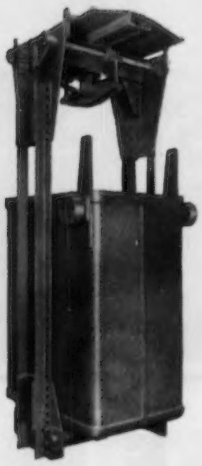


SLUSHER HOISTS
15 to 150 H.P.



ALUMINUM CAGES AND SKIPS





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For over half a century, Canton Equipment has saved lives, increased output, made money for operator.

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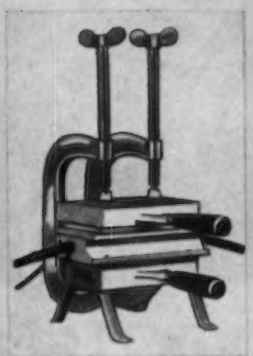
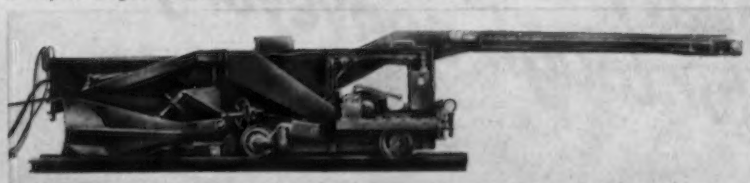
Model 30 Track Cleaner. Specially designed for fast cleaning. Quick acting hydraulic adjusting. American Mine Door Company tailors the machine for 24" to 48" track gauge, and from 30" up in height. Amortized in a few months.



Canton Cable Vulcanizer makes neat non-snag joint, stronger than original cable with "Canton" Cable Splicers. Save time, Save money.

"Canton" Car Transfer—Loads entire train on a single track. No alterations whatever to the main track. Less rib to shoot than for jump switch. No hazards of cherry picker. Car always on wheels.



The Rugged "Canton" Model 40 Track Cleaner. Tailored to your mine from 40" up in height. The "Canton" Track Cleaners save hundreds of dollars per mile in track cleaning costs. Pay for themselves in short time. Clean all mines, hard and soft coal mines, iron and copper, potash and salt mines.

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Let us install a "Canton" product for you. Pay us out of savings.

TAPER-LOCK SOLID STEEL CONVEYOR PULLEY

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—maximum strength
—minimum weight

2 **FULLY ENCLOSED**
no dust—no dirt—no water

3 **SUBMERGED-ARC PROCESS**
—full strength in all welds

4 **TAPER-LOCK BUSHING**
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—easy on—easy off!

DODGE-TIMKEN ALL-STEEL PILLOW BLOCK

5 **NEW HEAVY-DUTY TIMKEN ROLLER BEARINGS**
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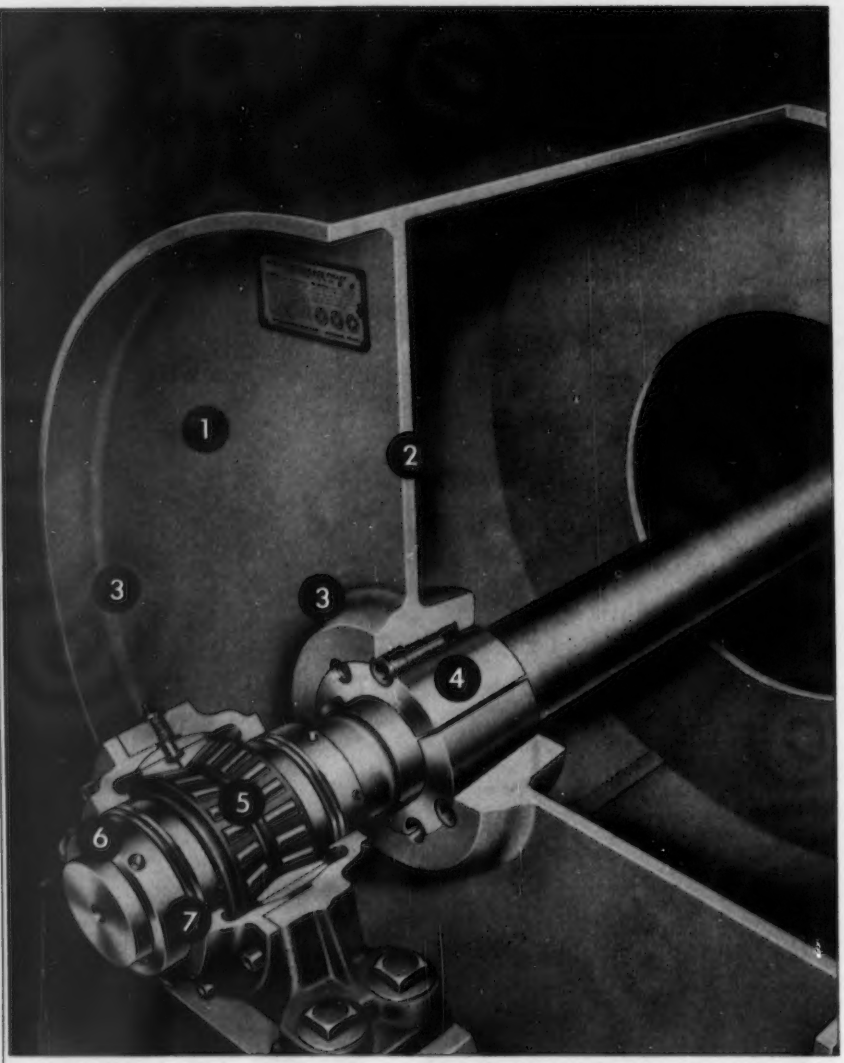
6 **HEAVY-DUTY ADAPTER MOUNTING**

7 **Sealed both on and off the shaft with DOUBLE PISTON RINGS**



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Pulleys from 6 in. to 8 ft. in diameter, all face widths. Bearings from 2 1/16" to 10" bores. Popular sizes stocked by our Distributors. Write for detailed information.

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Call the Transmissioneer, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.

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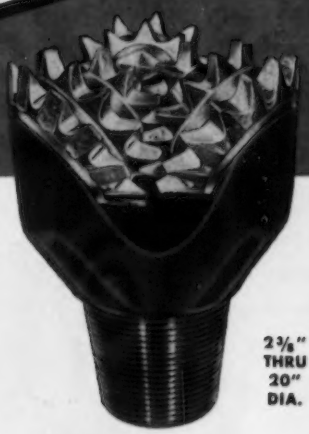
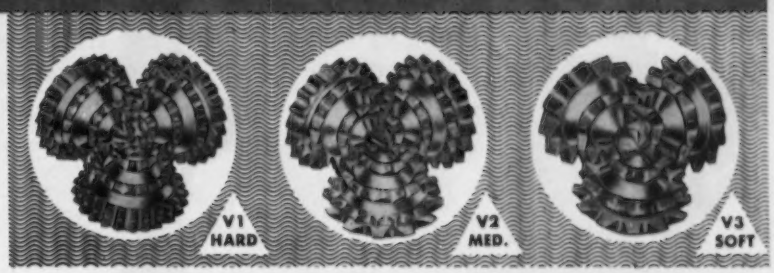


2⅜" THRU 20" DIA.



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For fast, clean drilling of blast holes or construction holes, specify **VAREL**. 'Regular' for Fluid Drilling and 'Air-Blast' for Air Drilling. Full information on types and sizes from 2⅜" thru 20" diameter available by mailing coupon.

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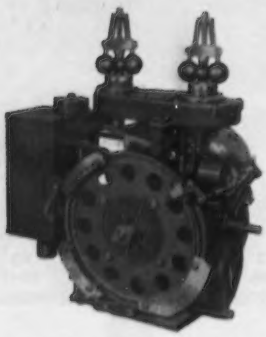
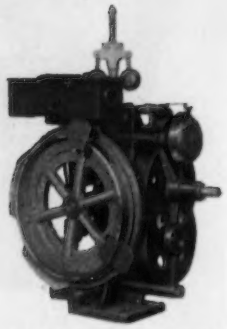


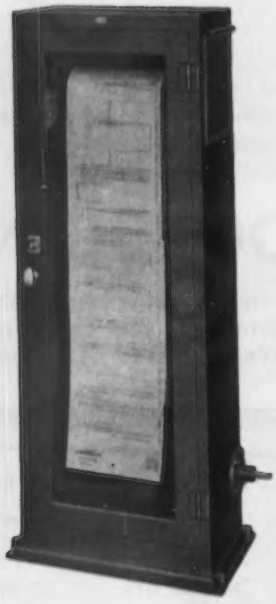
A MODEL C LILLY HOIST CONTROLLER with Duplex Governors. Model C Controllers are particularly suited to large and fast hoists. (See Catalog C-44)

A SIMPLEX HOIST CONTROLLER equipped with Depth Indicator and mounted on a Weight Unit with Regulating Cylinder for operating the brakes of small hoists. These units are best suited to small or relatively low speed hoists. (See Catalog S-46)

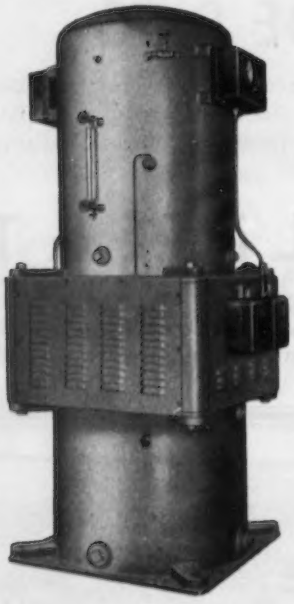


A MODEL D LILLY HOIST CONTROLLER assembled left hand. Model D Controllers are particularly suited to small or medium size hoists. (See Catalog D-44)

A MODEL C LILLY HOIST CONTROLLER with Single Governor, mounted on a Solenoid Valve Unit with Automatic Brake Regulator for hydraulically operated brakes.



LOGAN HOIST RECORDER for recording all movements and delays of the hoist, and to provide a graphic picture of the manner in which it is operated. (See Catalog 447)



LOGAN AUTOMATIC HYDRAULIC PRESSURE UNITS, for operating hydraulic brakes. Made in four standard sizes, 20, 30, 40 and 70 gallons per minute. (See Catalog 3-47)

A MODEL D LILLY CONTROLLER, mounted on Weight Unit with Regulating Cylinder for operating the brakes of small hoists.

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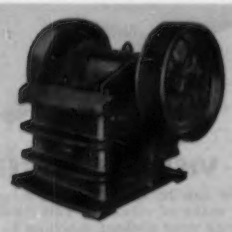
Crushers, Screens, Conveyors

Lippmann has specialized for 32 years in the design, construction and application of crushing, screening and conveying machinery for the pit, quarry and mining industries. Today, the Lippmann name on a piece of equipment is recognized as assurance of consistent high production, low-cost performance and reliability . . . and leading producers the world over prove it by repeat purchases of Lippmann machinery.

You, too, can look to Lippmann with confidence for the finest of equipment to meet your needs — for individual crushers, feeders, screens, conveyors, or washers — or for complete plants. Lippmann Engineering Works, 4623 West Mitchell Street, Milwaukee 14, Wis.



JAW CRUSHERS

Sizes up to 42 x 48 inches (the largest overhead eccentric jaw crusher made). Features 25% more crushing area, non-choking construction, maximum output, minimum power use and maintenance.

GYRATORY CRUSHERS

Revolutionary design results in lighter weight, less power consumption, reduced maintenance and controlled product size. Sizes 25 to 72 inches.

ROLL CRUSHERS

Offer real economy in secondary crushing. Exact product size control; tapered roller bearings; a variety of shell face patterns available; easily replaceable wear plates reduce maintenance. Sizes up to 72" x 24" rolls.

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Complete line of both portable and stationary conveyors. Lippmann Ever-Seal roller bearing conveyor idlers are outstanding for lower first cost and maintenance. Bearings are lubricated for life.

APRON FEEDERS

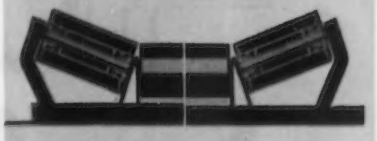
LIPPMANN makes apron feeders and plate feeders to meet all feeding requirements. Every design has been thoroughly proven by rigorous field service and built for long wear and low power requirements.

SCREENS

Vibrating screen pictured is positive eccentric type with equally distributed vibration for maximum capacity. Vibration contained in screen body entirely. All sizes, single and multi-deck.

BELT IDLERS

Lippmann, new design, improved belt idlers with more permanent lubrication retention, all welded steel design, and greater strength, are available in both Ever-Seal permanently lubricated type and special sealed regrease type — also with self-cleaning angle base or regular channel base.



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An unusual design of hammer-type crusher with unmatched records of capacity, product size and quality control, low first-cost and ease of maintenance. Manganese hammers, forged hammer arms and other outstanding design features. Sizes up to 40" x 36".

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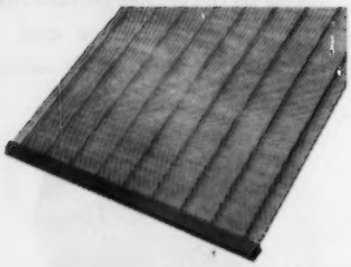
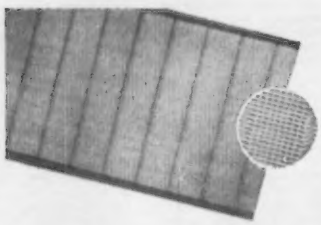
A new innovation in the mining and industrial field. Particularly adaptable for use in flumes. The screen guard is built right into the screen and the vertical guard bars keep the larger lumps of material above the guard bars, permitting only the finer particles to pass over the screen. Special sizes can be furnished.



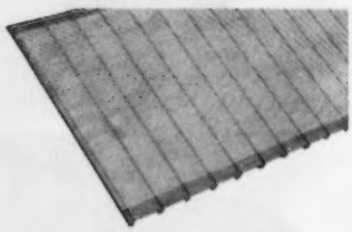
VIBRATOR SCREENS

They can be designed and adapted to fit any make of vibrator. You do not have to change your present machine to accommodate this screen. It is of quality construction and built to give maximum service. The rigid construction and method of installation prevents "whipping".



MARCEL-TYPE SCREENS

This screen is entirely different inasmuch as it is of a Marcel-type construction. It was designed for operations where slivers passing through are objectionable in the end product. This screen can be made in all sizes and shapes wherever applicable to higher and productive efficiencies. It gives long life and non-blinding operation.



ALUMINUM SCREENS

This aluminum screen has all of the attractive and sturdy features of many other metals. In addition, it offers flexing action that adds capacity and dewatering abilities which are almost unbelievable. No changes are necessary in the body of the screen to effect its installation.

NON-BLINDING — NON-CLOGGING - LONGER LIFE - MOST ECONOMICAL

The diagram at left shows all of the efficiency that can be furnished to you by KLEENSLOT Wedge Wire Preparation Screens, inasmuch as the wedge construction permits easy clearing. KLEENSLOT Wedge Wire Screens can be furnished in practically any type of metal. It costs nothing to obtain a Wedge Wire recommendation free of charge. Complete literature is available for the mining, oil, food, chemical and abrasives industry. There is a KLEENSLOT Wedge Wire Screen for every application.

WEDGE-WIRE CORPORATION

GAS STREET AND NICKEL PLATE R. R.
WELLINGTON, OHIO

GM DIESEL
CASE HISTORY NO. 537-42

USER: C. H. Snyder
Coal Company,
Cowansville, Pa.

INSTALLATION: GM "6-71"
2-cycle Diesel replaced
4-cycle Diesel in shovel
over 2 years ago.

PERFORMANCE: Owner
C. H. Snyder reports
better performance,
25% more production
with GM Diesel power.
GM Diesel starts faster,
uses less lube oil, gives
smoother operation.

It Pays to Standardize on

. . . available in more than 750 models of equipment built by over 150 manufacturers

GM
GENERAL MOTORS
DIESEL
POWER

Production up 25% with

GM DIESEL POWER

When his shovel was two years old, owner C. H. Snyder switched to General Motors Diesel power and upped production from 8,000 to 10,000 tons of coal per month. He converted to GM Diesel because these 2-cycle Diesel engines have given him dependable low-cost performance in a tractor, dragline, truck and another shovel.

Fast-accelerating, smooth-running GM Diesels do more work at less cost in new equipment or old. They start at the push of a button even in coldest weather—deliver power at every piston downstroke to speed operations, boost production. Low-cost parts are readily available and GM Diesel distributors back up GM Diesel performance with on-the-spot service. Call your distributor today—ask him about low-cost horsepower for *your* job.

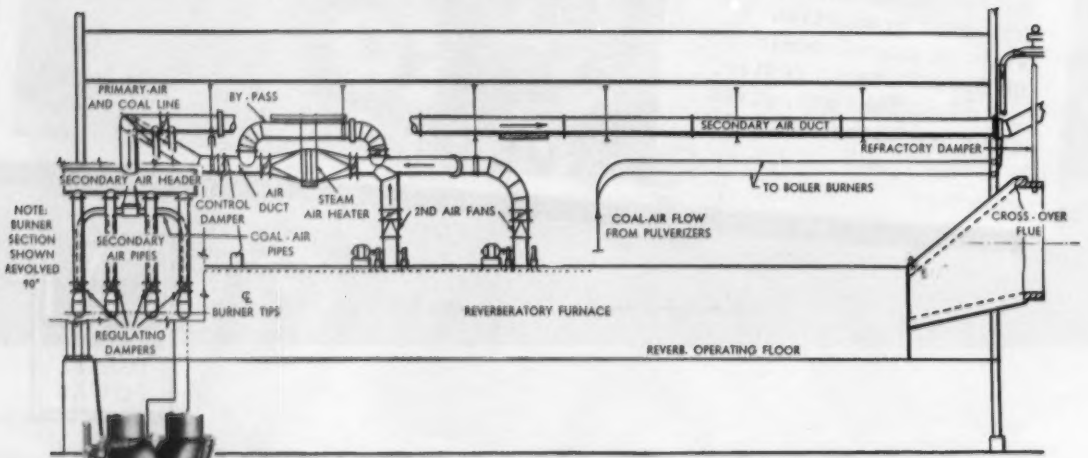
DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN
Single Engines . . . 30 to 300 H.P. Multiple Units . . . Up to 893 H.P.

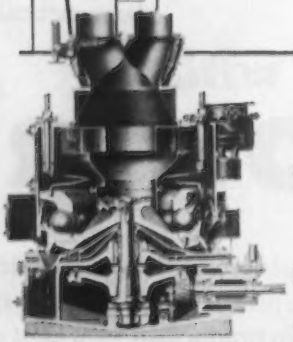
ON THE RECORD

B&W Fuel-Handling, Fuel-Burning

CUTTING PROCESSING METALLURGICAL

PULVERIZED-COAL FIRING





Section of B&W Coal Pulverizer used in direct-firing systems

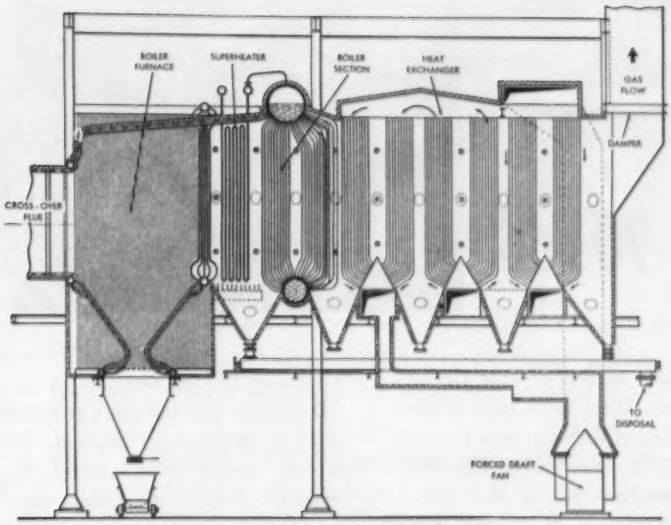
B&W Direct-Firing and Circulating Pulverized-Coal systems are serving a wide range of industrial furnaces of various capacities, which are often located in separate areas through a plant, with the coal supply to each independently controlled.

The solution of unusual problems common to firing industrial furnaces with pulverized coal is one of a number of plus values that can promote higher production, lower operating cost, and reduction of furnace maintenance. For plant expansion, modernization of metallurgical fuel-fired furnaces, and waste-heat recuperation, B&W offers broad research, engineering and production experience well worth investigating.

and Heat-Recovery Systems are

COSTS IN PLANTS

HEAT RECOVERY



For industrial furnace application, B&W single-pass, tubular-type heat exchangers used separately or in combination with waste-heat boilers, are designed to handle heavy, dust-laden, high-temperature, and corrosive gases from reverberatory furnaces, sulphide roasters, or other furnaces used in the non-ferrous metals industry.

Streamlined design results in low draft loss, operation under natural draft, and elimination of external corrosion — also affords effective cleaning with soot blowers.

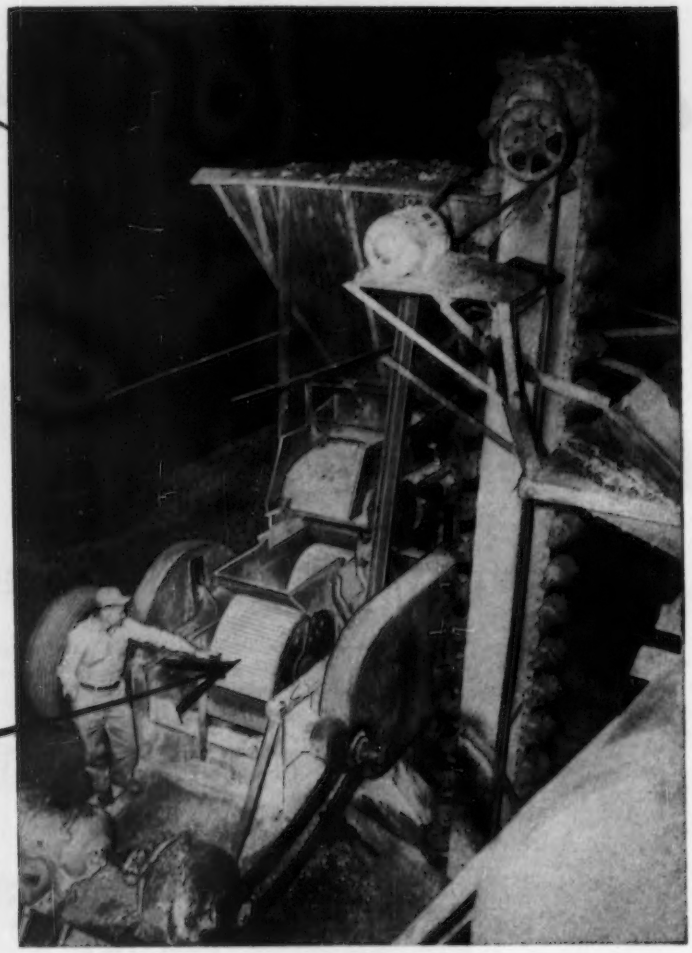
Use of the B&W tubular-type heat exchanger as an air heater or as a gas cooler in combination with a boiler, or separately, offers substantial savings. Whether used in a new installation or as part of a modernization project, it will afford fuel savings, lower unit operating cost as reflected by a higher rate of production and lower initial investment for a gas cooler in a new installation.

BABCOCK & WILCOX

BOILER DIVISION

G-706

Crushing Life Increased 500% by *Hard-Facing* with HAYNES 90 rod



Hard-facing the rolls in this crusher rig with HAYNES 90 Rod makes them more than 5 times more durable. Two sets of rolls are used to crush rock from 3-in. down to ½-in. screen size. They handle up to 26 thousand tons of rock with a minimum of repairs—despite severe wear from abrasion and impact. Other hard-facing materials wore out before 5,000 tons of rock were crushed.

Since HAYNES 90 Rod was adopted as the standard material on this job, production increased, down-time was reduced, labor and maintenance costs were cut, and less hard-facing material was needed per ton of rock crushed. This is typical of the kind of savings that can be realized by hard-facing with HAYNES alloys.

HAYNES hard-facing alloys give outstanding service when used to protect parts in crushers, shovels, tractors, trucks, conveyors, and other metal parts exposed to wear from abrasion, impact, corrosion, or heat.

Your local dealer carries a complete line of HAYNES hard-facing alloys, including: HAYNES iron and nickel-base rods, HAYNES STELLITE cobalt-base rods, and HAYSTELLITE tungsten carbide tube rods. Ask him for descriptive literature. If you don't know the location of your local dealer, write to Haynes Stellite Company, a Division of Union Carbide and Carbon Corporation, Kokomo, Indiana.

See... Your local Haynes Stellite Dealer

or

Write... to Haynes Stellite Company

"Haynes," "Haynes Stellite," "Haystellite" are registered trade-marks of Union Carbide and Carbon Corporation.

Unretouched photos of a typical installation of Buell's 'SF' Electric Precipitator used by a leading metal processor.

The scientific approach of Buell Engineers to your dust collection problem is backed by many years experience in the metals industry... finest research facilities... and a complete line of *proven-in-use* Dust Collection Systems.

TYPICAL BUELL USERS:

Aluminum Co. of America
American Cyanamid Company
American Potash & Chemical Corp.
Carbide & Carbon Chemicals Corp.
Cerro De Pasco Copper Corp.
Chase Brass & Copper Co.
Haile Gold Mines, Inc.
Ingle Coal Mine
National Lead Co.
Nicaro Nickel Co.
O'Okiep Copper Co., Ltd.
Phelps Dodge Corp.
Reynolds Metals Co.
U.S. Steel Corp.
Vitro Uranium Co.

MECHANICAL ELECTRICAL

- **Buell "SF" Electric Precipitators**

Thanks to such exclusive features as the Spiralectrode and continuous cycle rapping... the ultra high efficiency of the "SF" Electric Precipitators make them ideal for the recovery of superfine dusts, fumes and mists. These units have also won wide acclaim throughout the industry for their low operating costs and simple maintenance.

- **Buell High Efficiency Cyclones**

Single and multi-stage Cyclones will handle any gas volume over 300 c.f.m. with temperature up to 1500° F. They feature large diameter and exclusive "shave-off" design... for clog-proof high efficiency... long life... minimum maintenance.

WRITE FOR BOOKLET "The Collection and Recovery of Industrial Dusts" explains *all three* Buell Systems. Write Dept. C-19, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell®

20 Years of Engineered Efficiency in **DUST COLLECTION SYSTEMS**

FOR OPEN PIT

DART MODEL 30-SL

MODEL 30-SL—30 ton end dump. Full cab. 184″ wheelbase. 300 to 350 HP Diesel Engine with or without torque converter. 100,000 lb. Dart planetary rear axle with 20″ x 9″ air brakes—25,000 lb. front axle with 20 1/4″ x 5″ air brakes. 16:00 x 25, 24-ply front tires—18:00 x 25, 32-ply rear tires. Hydraulic steering—20 Cu. Yd. Rock Body. Approximate Weight, 46,000#.

OR UNDERGROUND

DART MODEL 18-S-UG-S

MODEL 18-S-UG-S—18 ton underground truck powered by 275 H. P. Diesel Engine with torque converter and fully reversible transmission. Hydraulic motor operates steel apron conveyor. Equipped with exhaust scrubber. Hydraulic steering. Operates as shuttle car. Height, 66′; width, 10′ 8″; length, 28′. Approximate weight, 39,000#.

Dart cuts costs!

DART 20S

DART 40SA

DART 10S

DART 75TA

DART TRUCKS

Kansas City 8 Missouri

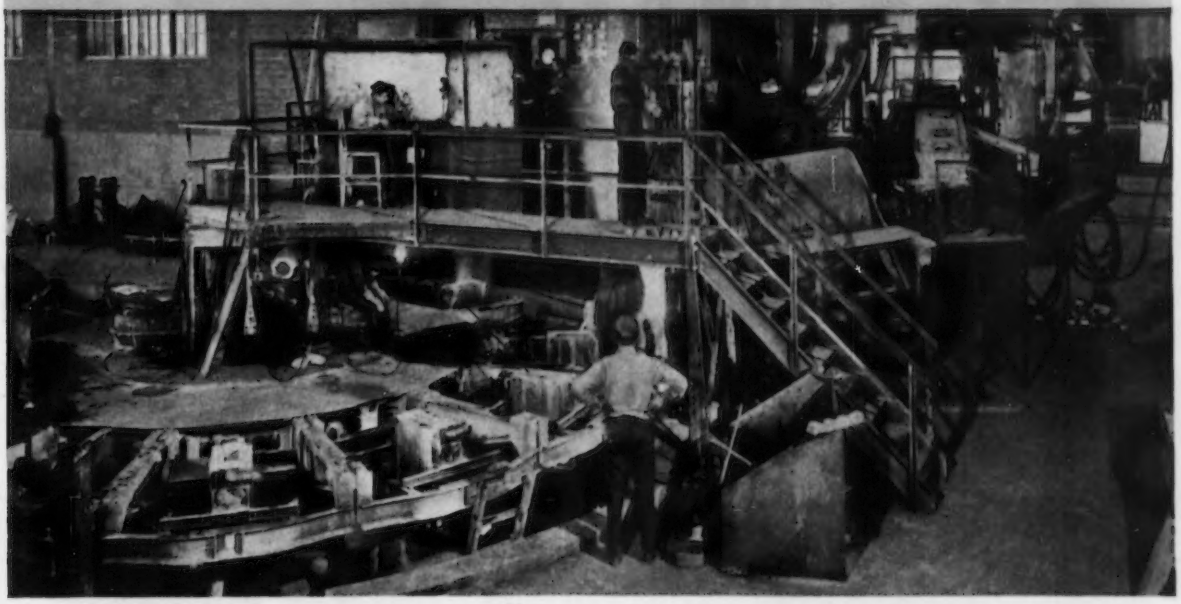
SUBSIDIARY OF THE CARLISLE CORPORATION

For the majority of its 51 years of engineering and building specialized heavy duty trucks, The DART TRUCK COMPANY has served the Mining Industry.

Dart engineering has produced many "firsts" in design which today are standard. The DART line includes models for mining ranging from 10 ton capacity through 75 ton capacity . . . the most complete line of off-highway trucks . . . all are built to provide maximum haulage with minimum maintenance, even under the most rigorous conditions.

SEE YOUR DART DISTRIBUTOR

WHERE EXPERIENCE COUNTS...



Design and manufacture of special equipment for smelting and refining

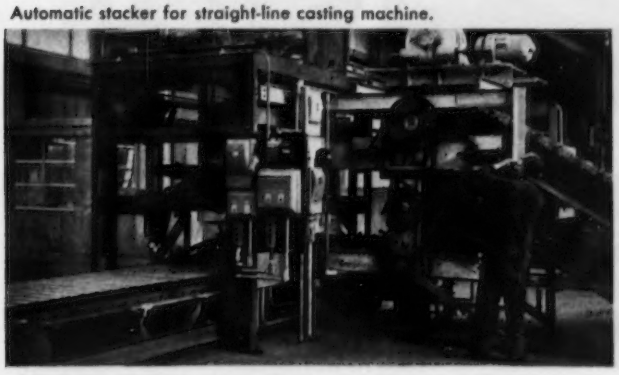
Whether it's a single piece of equipment or a complete plant layout, there's no substitute for Treadwell experience.

In all parts of the world, years of success in meeting every type of smelting and refining problem, have given Treadwell an intimate knowledge of the needs of non-ferrous metals producers.

Result: Treadwell's staff is well prepared to give you the most effective, cost-saving solutions to your problems. Treadwell equipment features many improvements designed to meet the demands of modern smelting and refining practice.

Our engineers will be glad to talk over your problems with you at any time.

Automatic stacker for straight-line casting machine.



SMELTING EQUIPMENT: LEAD BLAST FURNACES • COPPER BLAST FURNACES • REVERBERATORY FURNACES • COPPER CONVERTERS • STRAIGHT-LINE CASTING MACHINES • HOLDING (OR TILTING) FURNACES • ANODE CASTING WHEELS • SMELTING ACCESSORIES.

REFINING EQUIPMENT: CIRCULAR CASTING WHEELS • LADLE TILTING EQUIPMENT • REFINING ACCESSORIES.

DESIGN OF CONVEYING AND HANDLING SYSTEMS: FOR ORE, COAL, ETC.

DESIGN OF COMPLETE PLANTS FOR: SINTERING, ORE DRESSING, MINERAL BENEFICIATION, NON-FERROUS METALS SMELTING AND REFINING.

M. H. TREADWELL COMPANY, INC.
140 Cedar Street, New York 6, N. Y.
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TR-11

TREADWELL

NON-FERROUS
SMELTING AND REFINING
EQUIPMENT

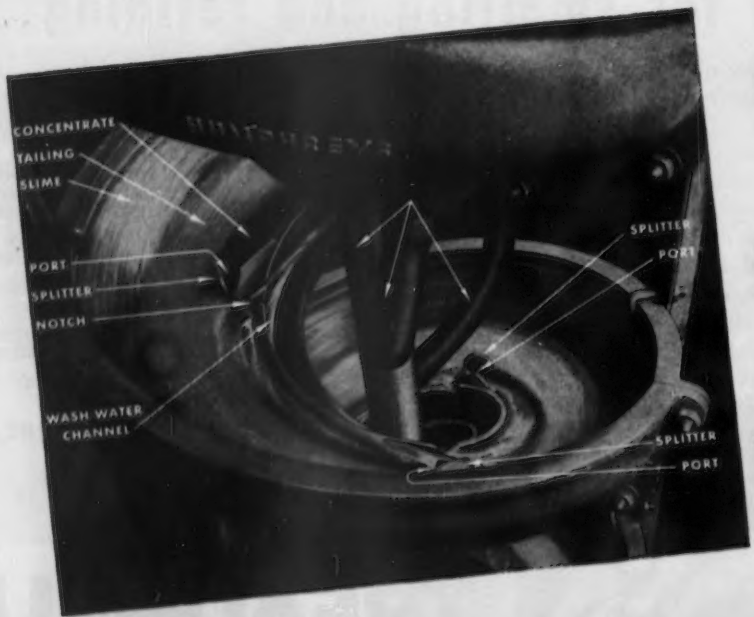
Is Your Mill Losing Values?

Investigate...

HUMPHREYS
Spiral Concentrators

Low-Cost Concentration

Humphreys Spirals offer low cost operation, maintenance, installation. Small floor space. No moving parts.



The Humphreys Investment Co.
ENGINEERING DIVISION

914 First National Bank Building
Denver 2, Colorado

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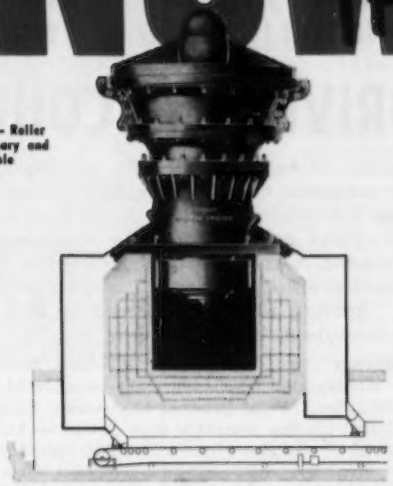
KNOWN THE WORLD OVER!



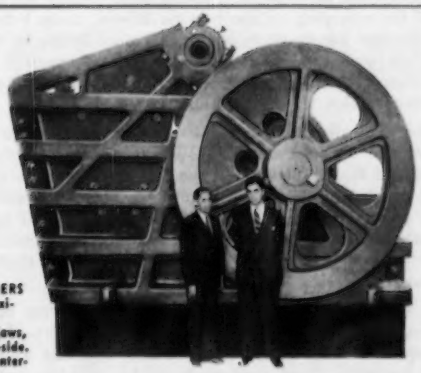
GYRATORY CRUSHERS – Roller Bearing, Gearless, Primary and secondary models. Double discharge outlets, synchronous motor built into pulley assembly or conventional V-belt drive. Power used only for crushing.

WHEREVER NON-METALLIC MINERALS ARE PROCESSED

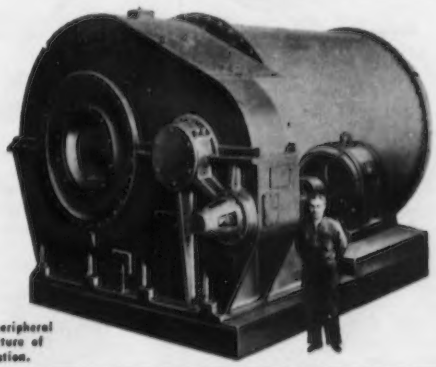
Machinery or equipment designed for crushing, grinding, screening and feeding — noted for dependability and low maintenance cost.

A half-century of experience in manufacturing mining machinery is built into every piece of KVS equipment. From the drafting board through the foundry, machine shop and erecting plant, rigid quality controls characterize our products.

KVS sales-engineers are available for consultation anywhere, anytime.

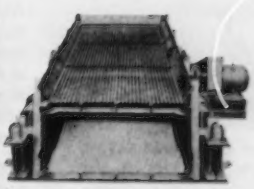


SWING JAW CRUSHERS – Heavy duty, maximum capacity and output. Reversible jaws, end-to-end, side-to-side. Kinetic power, counterbalanced fly wheel.

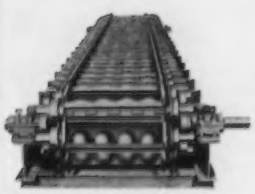


ROD MILL – Center peripheral discharge for manufacture of sand for fine pulverization.

AIR SWEPT TUBE MILL – Integral drive, for fine grinding and pulverization of coal, gravel, sand, etc.



VIBRATING SCREEN – One, two or three decks. Interchangeable mesh, four-way motion. Portable or stationary models.



HEAVY DUTY ROCK FEEDER – Built in any length or width. Overlapping pans for heavy duty service.

WRITE FOR BULLETINS DESCRIBING KVS MACHINERY AND EQUIPMENT

KENNEDY-VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

TWO PARK AVENUE • NEW YORK 16, N. Y. • FACTORY: DANVILLE, PA.

IT PAYS TO *Specify*

FALK DRIVES and COUPLINGS

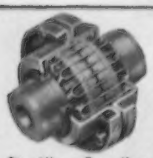
- A wider choice of standard designs
- Practical features exclusive to Falk
- Sound, progressive engineering
- In-built factors for long, efficient service

1. Motoreducers All-Motor Horizontal

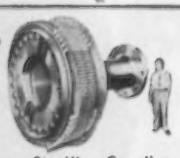
1. Motoreducers All-Motor Right Angle

1. Motoreducers All-Motor Vertical

2. Shaft Mounted Drives



3. Steelflex Couplings Standard or Dual Purpose



3. Large Steelflex Couplings for Heavy Duty Service

4. Airflex Couplings—For High Torque Fluctuations

5. Speed Reducers Large Parallel Shaft

5. Speed Reducers—Large Right Angle Horizontal

5. Speed Reducers—Large Right Angle Vertical

6. High Speed Gear Drives, Reducers or Increasers

7. Special Gear Drives for Any Application

7. Marine Propulsion Gears, Turbine or Diesel Driven

8. Helical Gears—Any Size

You can rely on Falk for top quality engineering and craftsmanship. For more than half a century, Falk engineers and production men have specialized exclusively in the design and manufacture of quality drives and couplings. This accumulation of experience and continuous research has produced a line of products noted for mechanical efficiency, long life, and progressive, practical design . . . products which have earned for Falk a good name in industry throughout the world.

1. **Motoreducers** . . . The famous All-Motor Motoreducer uses any standard foot-mounted motor within the capacity of the gear unit. All-steel construction; helical gearing. Horsepower range from 1 through 75 hp. Output speeds: concentric shaft design — from 1.8 to 580 rpm; right angle shaft design — from 1.2 to 350 rpm. Ratios up to 54,000:1 in special units. Integral design also available, from 1 through 40 hp.
2. **Shaft Mounted Drives** . . . A variation of the Motoreducer design, adapted for mounting on shaft to be driven, using V-belt connection to motor. All-steel construction, helical gearing. Single or double reduction units in six sizes. Horsepower range from 1 through 30 hp. Output speeds from 420 to 14 rpm. Offset shaft design provides means for adjusting belt tension by using turnbuckle on tie-rod.
3. **Steelflex Couplings** . . . Exclusive grid-groove design smothers shock and vibration, accommodates reasonable degrees of shaft misalignment and free end float. The basic Type F is applicable to more than ninety per cent of all industrial applications, horizontal or vertical. Thirty-three sizes to cover capacities from 2/5 through 70,000 hp per 100 rpm (basic rating). Special or dual purpose Steelflex designs available for problem applications. Almost a million Steelflex couplings have gone into industrial service.
4. **Airflex Couplings** . . . Protect machinery against damage from impacts resulting from irregular torque characteristics of prime mover or driven machine. Require no maintenance. Provide electrical insulation between machines. Dual purpose types for problem applications.
5. **Speed Reducers** . . . Falk precision cut helical or spiral bevel gears produce highest attainable mechanical efficiencies. Sturdy housings, liberal bearing capacities, positive lubrication. ***Concentric Shaft Reducers:*** from 1 through 150 hp; ratios from 1.5:1 to 970:1. ***Parallel Shaft Reducers:*** from 15 through 3000 hp; ratios from 2:1 to 300:1; sleeve or roller bearing units. ***Small Right Angle Reducers:*** horizontal or vertical output shaft; from 1 through 200 hp; ratios from 5:1 to 1450:1. ***Large Right Angle Reducers:*** with horizontal output shaft — from 15 through 1000 hp, with ratios from 1.5:1 to 515:1; with vertical output shaft (up or down) — from 15 through 700 hp with ratios from 6:1 to 430:1.
6. **High Speed Drives** . . . For use as reducers or increasers. Quiet operation, high efficiency. Standard units: horsepower range through 5000 hp; maximum speeds ranging from 4500 to 9000 rpm. Special designs: horsepower ratings through 21,500 hp and higher; output speeds above 50,000 rpm, if required.
7. **Special Gear Drives** . . . Falk engineering experience and complete production facilities have designed and produced gear drives for almost any application . . . from sturdy, slow speed mill drives . . . to large marine propulsion drives . . . to ultra high speed drives.
8. **Single Helical or Herringbone Gears** . . . For any application. Hub gears, ring gears, mill pinions. Precision cut, Falk improved tooth form. Face widths up to 6 ft or more. Diameters up to 18 ft. Gears made of Falk alloy steels; pinions made from steel forgings. Full load efficiency of 98% per train.

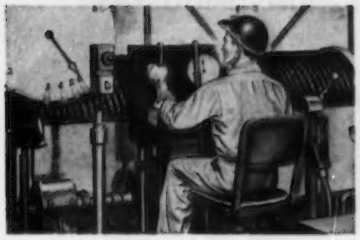
THE FALK CORPORATION

3049 W. Canal Street, Milwaukee 8, Wisconsin

REPRESENTATIVES AND DISTRIBUTORS IN MOST PRINCIPAL CITIES

M.S.A. MINEPHONE

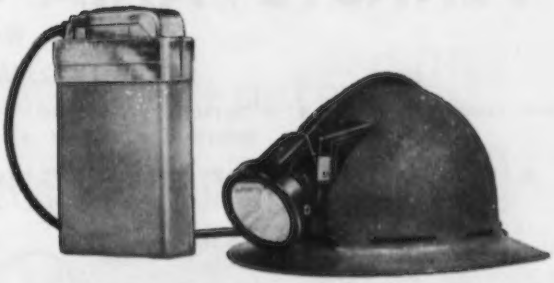
Messages are dispatched instantly to all motormen, who can receive and reply while trips are in motion. System keeps main line haulage-ways free of traffic tie-ups; reduces errors and accidents; prevents excessive stop-and-start strain on equipment.



M.S.A. HOISTPHONE

Continuous, clear voice communication between hoisting engineer and cage, at any level, and while cage is in motion. Ideal for safer load leveling, inspection trips, shaft repairs. Utilizes existing wiring. ALSO —M.S.A. PORTABLE HOISTPHONE—compact unit can be set up anywhere, put into immediate service. Permits temporary communication for inspection work, emergency jobs.

EDISON R-4 ELECTRIC CAP LAMP— M.S.A. TYPE K SKULLGARD



More and better illumination for today's modern mining methods. The R-4 Lamp's brilliant, unfailing illumination lets miners work faster, better, safer. The famous Type K Skullgard, is strong, light, durable. Maximum head protection that is not affected by oil, water, perspiration.

These M. S. A. products can help answer
YOUR PRODUCTION-SAFETY NEEDS

M.S.A. SELF-RESCUER

For immediate breathing protection in emergencies. Vital to the miner while traveling through carbon monoxide to fresh air. Available in cache assemblies for storage throughout the mine, or in individual carrying cases. U.S. Bureau of Mines Approved.

M.S.A. CHEMOX

Provides complete breathing protection in any atmosphere. Chemox generates its own oxygen from replaceable chemical canister. Weighs only 13½ lbs. Comfortable in service. U.S. Bureau of Mines Approved.

M.S.A. DEMAND WORK MASK

Breathing protection for planned work in toxic atmospheres. Mask provides self-contained air or oxygen supply. Connecting hoses lets wearer move freely. Manifold arrangement permits use of more than one unit from a single cylinder.

M.S.A. DUSTFOE RESPIRATOR

Maximum protection against dusts. This unit is compact, very light in weight. Its design eliminates "blind-spots," provides wearing comfort that encourages full-time use. U.S. Bureau of Mines Approved.

M.S.A. CHEMKLOS

Made throughout of Dynel, the new fabric that resists acids and caustics, M.S.A. ChemKlos answer the need for longer-wearing, smarter-looking work clothes. Special weave for maximum resistance to abrasion. Also, miner's rubber suits, boots, etc.

M.S.A.-LAMB AIR MOVER

Practical, portable ventilating device that uses only compressed air or steam. No motors, turbines, fans. Three sizes—largest size moves as much as 5,160 cu. ft. air per min. Forces air in, or sucks fumes out.

M.S.A. RAIL PUNCH

Makes quick, safe work of punching holes through web sections without need of external power.

M.S.A. PNEOLATOR

Portable, self-contained automatic artificial respiration device. Accepted by A.M.A.

also—a complete line of portable instruments for detecting CO, H_2S, SO_2, HCN. Instruments for collecting, sampling, counting dusts. First aid kits and materials.

MSA
SAFETY EQUIPMENT HEADQUARTERS

When you have a safety problem, M.S.A. is at your service. Our job is to help you.

MINE SAFETY APPLIANCES COMPANY
201 North Braddock Avenue, Pittsburgh 8, Pa.
At Your Service: 77 Branch Offices in the United States and Mexico

MINE SAFETY APPLIANCES CO. OF CANADA, LTD.
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PENNSYLVANIA CRUSHER DIVISION

Bath Iron Works Corporation

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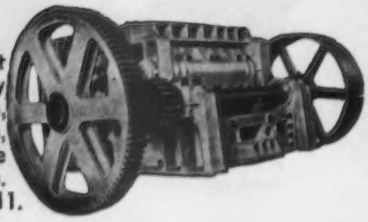
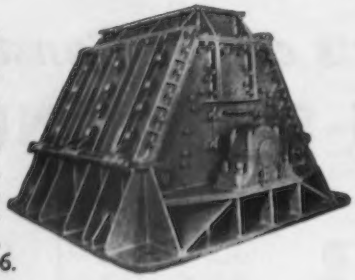
A COMPLETE LINE OF CRUSHING EQUIPMENT FOR THE MINING INDUSTRY

SINGLE ROLL CRUSHERS



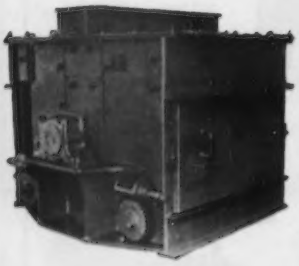
For efficient, low-cost primary and secondary reduction of coals, ores, chemicals, limestones, gypsums, etc. Wide range of capacities. Send for Bulletin #2011.

REVERSIBLE IMPACTORS



Reversible rotation. Reduces by direct impact at controlled slow speeds. Produces particles cubical in shape, uniform in size. For high silicas, clinkers, slags, ores, furnace refractories, limestones, gypsums, chemicals, etc. Send for Bulletin #6016.

REVERSIBLE HAMMERMILLS

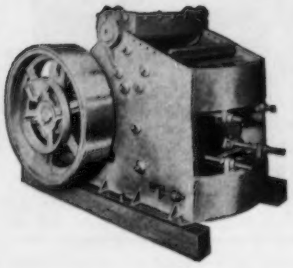


For secondary or tertiary crushing of a wide range of rocks, minerals, ores and chemicals. Reversible rotation. Two zone crushing—impact and attrition. Great reduction ratios. Lower hammer and cage maintenance. Less H.P. required. Send for Bulletin #1034.

GRANULATORS RING TYPE

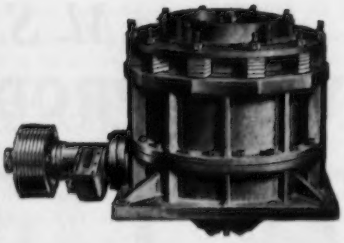
For preparing industrial steam coals (for pulverizers and stokers), limestones, gypsums, chemicals, etc., with minimum overgrinding. Adjusted cage. Send for Bulletin #9002.

KUE-KEN JAW CRUSHERS



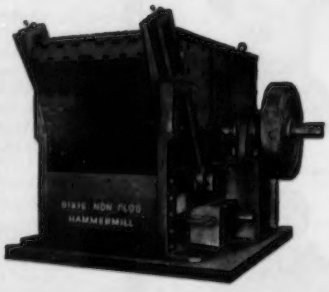
A favorite in the metal mining industry. Crushes toughest ores economically. Minimum wear, power and fines. Delivers more strokes per minute. Sealed so dust can't enter, oil can't escape. Send for Bulletin #5012.

KUE-KEN GYRATORY CRUSHERS



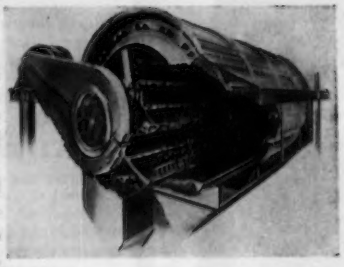
Crushes by pressure only. Does not rub ore. Pre-tested lubrication. Has over-load release. Shaft five times stronger than ordinary crushers of this type. Send for Bulletin #500.

DIXIE NON-CLOG HAMMERMILLS



The patented Non-Clog Moving Breaker Plate in Dixie Hammermills eliminates troubles when crushing wet or sticky material that would clog other types of hammermills. Send for Bulletin #1050.

BRADFORD BREAKERS AND BRADFORD HAMMERMILLS



For primary screening and crushing of coal at the mine. Also widely used for preparation of ROM coals at By-Product Coke Plants and Central Stations. Massive, Steelbuilt, with a large factor of safety. Send for Bulletin #3007.

THE RIGHT CRUSHER FOR ANY JOB IS THE MACHINE THAT GIVES THE DESIRED FINISHED PRODUCT, IN THE VOLUME PER HOUR REQUIRED, AT THE LOWEST COST PER TON.

PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION

No one type of Crusher meets all requirements. That's why Pennsylvania has a varied line, which, incidentally, assures you of an unbiased recommendation from Pennsylvania Engineers. Let us analyze your crushing problems; the materials you want to crush are tested in a crushing set-up that duplicates your operating conditions, guarantees results before you go to the expense of purchasing and installing equipment. Write for Bulletins. We also make custom built crushers for special crushing jobs.

A startling announcement to crawler-type machine owners:

NOW! sterling TRACK ROLLERS

reduce grease cost over 90%

reduce greasing time over 90%

1,500 hours of continuous operation without greasing

Most manufacturers of crawler-type machines recommend track roller greasing every eight hours. But with STERLING track roller replacements, greasing is specified *only after 1,500 hours* of continuous operation!

Because of an entirely new concept in track roller design, engineered by Sterling Steel Casting Company (patent pending), your savings are almost unbelievable. For example, if you grease your present rollers every eight hours, during a normal year's operation, your grease cost alone will be more than $500 per 12-roller tractor, compared to a grease cost of only $5.40 with STERLING track rollers!

During a normal year's operations, about *172 man hours* of labor will be consumed greasing your present rollers; greasing time on STERLING track rollers would be about *two man hours!*

Even if you run your present rollers for as long as 40 hours without greasing, your savings on grease and labor are still tremendous.

Although STERLING track rollers cost about 20 per cent more than ordinary rollers, Sterling Steel Casting Company unconditionally guarantees its STERLING track roller replacements to last at least 20 per cent longer, when operating under the same conditions.

For complete information, write today. We'll be glad to send a representative to see you at your convenience.

Replacement rollers for D-8, D-7, HD-19, HD-20, TD-24

- ✓ Dual Wheel Design
- ✓ Anti-Friction Tapered Roller Bearings
- ✓ Alloy Cast Steel, Heat Treated to Brinell Hardness of 500-600 on Tread & Flange
- ✓ Positive Seal Keeps Grease In, Dirt and Dust Out
- ✓ Recommended Lubrication: Every 1,500 Hours

sterling

STEEL CASTING COMPANY

East St. Louis, Illinois • BRidge 1-2111

EXPORT DIVISION

STERLING STEEL CASTING CO.

8 So. Michigan Ave., Chicago 3, Ill

Cable Address: "STERCASCO"

MAIL COUPON NOW!

STERLING STEEL CASTING COMPANY
EAST ST. LOUIS, ILLINOIS

Gentlemen: Send complete information and price list on your new STERLING track rollers for the type of equipment checked below:

☐ D-8 ☐ D-7 ☐ HD-19 ☐ HD-20 ☐ TD-24

Please send your representative to see me on

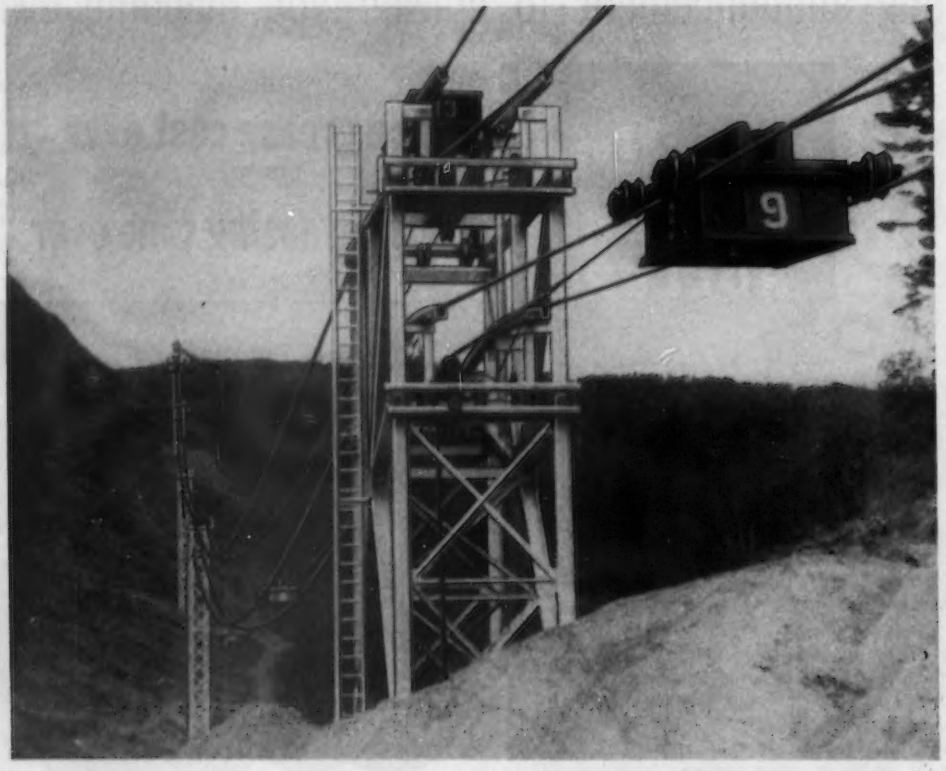
_____, at _____
(Month & Day) (Time)

Name_____

Firm_____

Address_____

City_____ State_____



INTERSTATE TRAMWAYS *are doing the work!*

CONVEYING and STOCKPILING ORE—COAL—STONE
REFUSE DISPOSAL at MINE and SMELTER

• The Heaviest Anywhere

AT HANNA COAL AND ORE CORPORATION'S
NICKEL MT., OREGON PROJECT

Lowering 250 tons per hour of nickel ore
Vertical drop 2,200 ft. Length 8,300 ft.
With a 2" diam. endlesss haul rope and a
600 HP motor drive which, in braking the
load and controlling line speed, generates
enough power for all mining demands.

WE BUILD ALL TYPES
OF AERIAL TRAMWAYS
doing the WHOLE JOB
from preliminary discussions
to complete operation.
MAINTENANCE, TOO!

—LET'S DISCUSS YOUR PROBLEM—

INTERSTATE EQUIPMENT DIVISION

YARA ENGINEERING CORPORATION

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ELIZABETH 4, N.J.

937 UNION TRUST BLDG.
PITTSBURGH 19, PA.

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EXPORT OFFICES: EIMCO BLDG., 52 SOUTH ST., NEW YORK CITY

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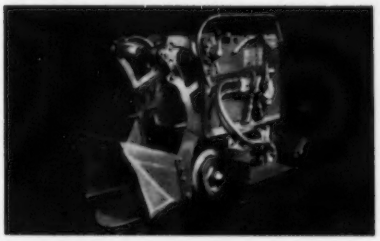
EIMCO ROCKERSHOVELS



MODEL 12B

SPECIFICATIONS		
Overall Width	28″	711 mm
Overall Length (caging)	44″	1117 mm
Overall Length (bucket down)	73″*	1854 mm*
Headroom Required	78½″*	1994 mm*
Clean-up Range	83″†	2108 mm†
Weight	4500#	2042 kilo

*Standard †Without side plow

The smallest of the RockerShovels requires minimum space for caging. Available with track gauges from 15″ to 36″. Loading speed 20 to 35 cu. ft. per minute depending on material handled. All parts alloy cast steel. Heavy-duty antifriction bearings used throughout. Available in Air or Electric.

MODEL 21

SPECIFICATIONS		
Overall Width	33½″	851 mm
Overall Length (caging)	55″	1397 mm
Overall Length (bucket down)	87″*	2210 mm*
Headroom Required	88″*	2235 mm*
Cleanup Range	98″†	2489 mm†
Weight	7200#	3265 kilo

*Standard †Without side plow

Medium sized RockerShovel. May be easily caged on most mine cages. Available in track gauges between 18″ and 48″. Loading speed 35 to 50 cu. ft. per minute depending on material to be loaded. Constructed of alloy cast steel parts with heavy-duty antifriction bearings throughout. Available in Air or Electric.

MODEL 40H

SPECIFICATIONS		
Working Length (bucket down)	20′8½″	6312 mm
Headroom Required	8′0″	2438 mm
Belt Width	28″	711 mm
Cleanup Range	12′†	3657 mm†
Weight Complete	16,850#	7643 kilo

†Without side plow

Largest rail type underground RockerShovel. Available in standard track gauges between 28″ and Standard Railroad or larger. Loading speed 60 to 100 cu. ft. per minute. This model can be furnished to tram on 24″ gauge tracks. Cast alloy steel parts are used throughout with heavy-duty antifriction bearings. Available in Air or Electric.

MODEL 15

SPECIFICATIONS		
Overall Width	5′9″	1752 mm
Overall Length	10′2″	3099 mm
Weight with Hopper	8000#	3629 kilo
Weight with Conveyor	9310#	4223 kilo
Load Capacity (live load)	6000#	2722 kilo
Turning Radius (hopper model)	7′4″	2235 mm

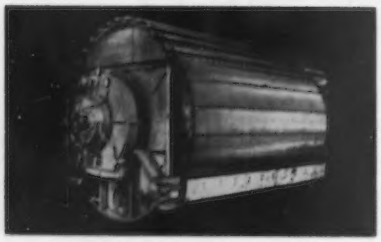
Rubber tired RockerShovel loading machine. It is actually a self-loading truck. Moves forward or reverse. Available with hopper, flat or inclined conveyor. Capacity 20 to 40 yards per hour depending on material loaded and length of haul. Available with AC or DC Electric motors or Gasoline engines.

EIMCO AIR LOCOMOTIVES

SPECIFICATIONS		
Receiver Size	32 x 84	40 x 84
Width Overall	32″	40″
Height Above Rail	48½″	48½″
Wheelbase	30″	30″
Working Pressure, p.s.i.	110	110
Approximate Weight	2790#	3260#

The only Air Locomotive with a two speed constant mesh transmission. This permits starting the load with maximum power and shifting to high speed for less air consumption per foot of travel. All receivers meet A.S.M.E. code for unfired pressure vessels and each receiver is inspected and serialized.

EIMCO FILTERS

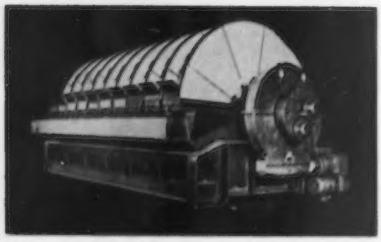


DRUM FILTERS

Face/Lgth. Diam.	SQ. FT. FILTER AREA 2′	4′	6′	12′	14′	18′
4	25	50	75			
6		75	113	226		
8			150	300	350	
10				376	440	
12				450	527	678

Also available in larger, smaller, intermediate sizes.

Drum Type Eimco Filters feature individual design, deep drainage sections, greater piping area and large streamlined valves. Materials of construction are specified for each filter and may be of stainless steel, monel, everdur, mild steel, clad materials, wood, and others with rubber, lead or other protective coverings.



DISC FILTERS

Disc No. Diam.	SQ. FT. FILTER AREA 1	2	3	6	10	12
4′0″	22	44	66	132		
6′0″	50	100	150	300	500	
8′0″			280	560	930	1115
12′6″				1200	2000	2400

Also available in larger, smaller, intermediate sizes.

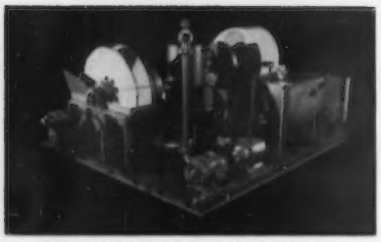
Eimco Disc Type Continuous Vacuum Filters are available in several designs consistent with slurry characteristics. Disc sectors are made in wood, metal, plastic, rubber or combination designs. Materials of construction vary with product to be filtered and local conditions under which machine must operate.

AGIDISC FILTERS

Disc No. Diam.	SQ. FT. OF FILTER AREA 1	2	3	6	10	12
4′0″	22	44	66	132		
6′0″	50	100	150	300	500	
8′0″			280	560	930	1115
12′6″				1200	2000	2400

Available in smaller and intermediate sizes not listed.

The agidisc has been successfully employed in the filtration of many heavy, fast settling metallurgical concentrates. It is especially adaptable when particles in suspension may be of a comparatively wide range, where the density of feed is low or settling rapid.



PLATFORM FILTER STATIONS

For sizes available see tables of Drum & Disc type filters. Top feed dewaterers and dryers can also be furnished for this type unit which is particularly adaptable for small units. Units are available for wet or dry vacuum set ups and for single or double solution.

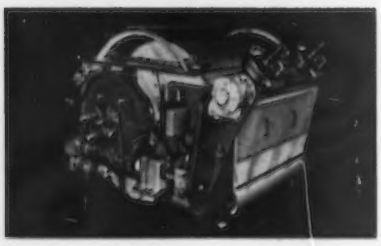
Platform or package filter stations are small drum, disc, pan, plate and frame or pressure units on a structural steel subbase with necessary equipment for small or pilot plant filter stations. Auxiliary equipment consists of: receivers, vacuum pumps, filtrate pumps, blower, motors, piping and a control control panel.

LAB FILTERS

DRUM
18″ Dia. x 12″ face
4 sq. ft. filter area
18″ Dia. x 24″ face
8 sq. ft. filter area
DISC
1 Disc 18″ 2 sq. ft.
2 Disc 18″ 4 sq. ft.

Stainless, monel, lead, iron, steel drum one piece cast. Individual panel covering feature.
Wood or metal disc sectors side caulking feature permitting use of small pieces of filter media.

Eimco stations for Pilot Plant or Laboratory use are specially constructed complete filter plants. These units include all necessary operating equipment for a filter station, compactly assembled on a flat platform or in a cabinet. Materials to specifications. Single or double solution units.



PRECOAT FILTERS

Face Diameter	2′	4′	6′	8′	10′	12′	14′	16′
4′	25	50	75					
6′		75	113	150	138	226		
8′			150	200	250	300	350	400

Eimco Precoat filters are available for open, vapor and pressure tight requirements. Eimco Precoat filters are the only filter that can be converted from open type to vapor or pressure tight construction in the field without changing the existing unit. Eimco's give higher filter rates, longer precoat and machine life, better product clarity, fully automatic operation.

PRESSURE FILTERS

Standard Drum ..... Max. 8′ dia.
Standard Disc ..... Max. 8′ dia.
Standard Agidisc ..... Max. 8′ dia.
Top-Feed Dryers ..... Max. 6′ dia.
Precoats ..... Max 8′ dia.
Pressures up to 150 p.s.i. and all pressure vessel fabrication can be to A.S.M.E. Code.

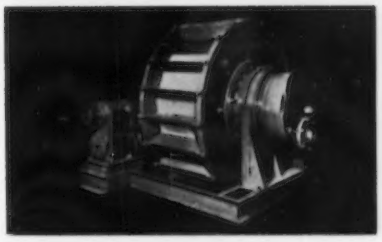
Eimco Continuous Pressure filters are available in either drum or disc design inside the pressure vessel. The vessel is designed for the desired pressure and the drum, disc or precoating unit is mounted inside the pressure tank. Discharge of the cake is by means of sealed screw conveyors or pressure tanks.

DEWATERERS

Face Diameter	3′	4′	5′	6′
1′	9.5	12.5	15.7	18.8
2′	19.0	25	31.4	37.6
3′		37.5	47.1	56.4
4′			62.8	75.2
5′				94

Other sizes made to specifications.

Eimco top-feed dewaterers are designed to provide a high capacity unit for dewatering the slurry. Especially adapted for slurrys with fast settling solids. Eimco's Dewaterers have a sturdy construction of heavy duty castings and steel weldments and can be mounted on a structural steel subbase for easy installation.

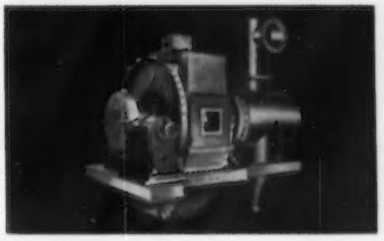


DRYERS

Face Diameter	3′	4′	5′	6′
1′	9.5	12.5	15.7	18.8
2′	19.0	25	31.4	37.6
3′		37.5	47.1	56.4
4′			62.8	75.2
5′				94

Other sizes made to specifications.

Eimco top-feed drum-type continuous vacuum dryers are particularly suited for granular or crystalline materials which are fast settling in solution and difficult to filter on standard drum or disc type units. The machine incorporates a streamlined hooded assembly to direct heated air flow through cake and receiver.



EIMCO-BURWELL FILTERS

The Eimco-Burwell Filter represents a radical departure from the ordinary plate-and-frame type filter, from the standpoint of design, washing efficiency and labor requirements. Any product now being processed through a plate-and-frame filter will be more efficiently treated on an Eimco-Burwell Filter. The Eimco-Burwell Filter gives you all the advantages of a plate-and-frame filter plus unparallelled speed of operation, high washing efficiency and low labor requirements.

The Eimco-Burwell Filter is composed of two sets of circular frames, each pair being mounted at 180° of each other (on a common shaft) in the same vertical plane. In operation, the common axis of the two frames is horizontal with one frame between plates and the other is extended in cleaning position.

With the Eimco-Burwell Filter the following advantages can be expected on most materials: Faster opening and closing of the plates on the frames. Drier cakes. Highly efficient washing, "Double plus." Uniformly dense cakes over entire surface of filter media. Practically no time lost to change frames. Eliminate all down time for cleaning frames. Lower requirements in filter surface. Plus many more advantages.

Approximate break down time for a typical 35-minute operating cycle on 30 frame unit:

Feed	15 min		
Wash	10-12 min.		
Blow	2-3 min.	Operating Position	CLEANING
Open, Rotate			Done while empty frames out in open.
Inspect, Close	5-6 min.		

CAKE HOLDING CAPACITY IN CU. FT.

SIZE OF FRAMES	7 FRAMES	10 FRAMES	14 FRAMES	20 FRAMES	30 FRAMES
1″	2.2	3.1	4.3	6.1	9.2
1½″	3.2	4.6	6.4	9.2	13.8
2″	4.3	6.1	8.6	12.3	18.4
2½″	5.4	7.7	10.7	15.3	23.0
3″	6.5	9.2	12.9	18.4	27.6
□′ AREA OF FILTER	51.6	73.7	103.2	147.4	221.1

EIMCO TRACTORS

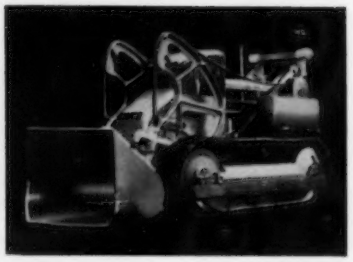
630 Tractor — Small Eimco Crawler type RockerShovel ideal for trackless operations underground. Available with Air or Electric motors. Independent control of each track. Heavy-duty construction throughout. Loading capacity 600-800 tons per shift depending on rock and haulage equipment available. Headroom required 6'8", min. width 5'8⅜", including step plates. Length, bucket down, 9'4." Also available as bulldozer for work in stopes or rooms.

105 Tractor — Eimco crawler type prime mover with Diesel power. Available with bulldozer, loader (as shown, right) or with many other attachments. Drilling front, sides and rear will accommodate any accessory equipment with standard S.A.E. drilling. Eimco tractor has Unidrive transmission, an exclusive feature, which includes all necessary gearing and clutches for forward, reverse and turns. Clutches never need adjustment. All motions of tractor controlled with two small handles. Operator position up front for full visibility. Loader excavator attachment designed for rock work. Loading capacity 6-8 cubic yards per minute.

Tractor dimensions: Overall height 7'3", overall length (base) 12'6", track gauge 74".

Standard shoe 16", weight 26,000 bare, drawbar pull (calculated) max. with grousers at zero track slippage 40,000 lbs.

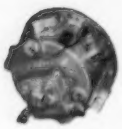
Excavator dimensions: Headroom required 13'6" (std.), overall length bucket down 16'6" (std.).



OTHER EIMCO EQUIPMENT

AIR HOSE

Eimco Air Hose — extremely flexible wire braid. Neoprene tube that will not collapse. Natural rubber cover treated for resistance to abrasion and impact. Will not sun check. Available in sizes of ½" to 4" with or without connections. Write for bulletin H4003.



AIR MOTORS

Eimco Air Motors are five cylinder radial type motors for reversible or non-reversible service. Heavy-duty construction with special attention to streamlined air passages make the Eimco the most efficient air motor on the market. Write for bulletin L1026.

LINERS

Utaloy Ball, Rod and Tube mill liners. An alloy cast steel, representing the ultimate in controlled microstructure. For longer mill runs and reduced grinding costs. Actual job data shows that "Utaloy" liners will grind more tons per set. Write for Utaloy "SQ", bulletin C3003.

GEARED AIR MOTORS

Eimco Air Motors are five cylinder radial type. Either flange or pedestal mounted or in a variety of gear reductions with a full range of speed reduction units. Precision made. Reversible. High starting torque. Dynamic and static balancing for highest efficiencies and smooth operation. Write for bulletin AE6001.

BALL MILLS

Eimco cylindrical type ball and rod mills with either central overflow or grate discharge are available in a wide variety of sizes. Any Eimco mill can be converted from central overflow to grate discharge or vice-versa. Extra heavy-duty construction. Write for information and specifications.

FOLDING SCRAPERS

Eimco Folding Scrapers are heavy-duty high capacity scrapers. Folding feature makes scraper require less power on return pull and dig in for full load on every trip. Cast of abrasion and impact resisting alloy steel. Write for bulletin C3004 for information and specifications.

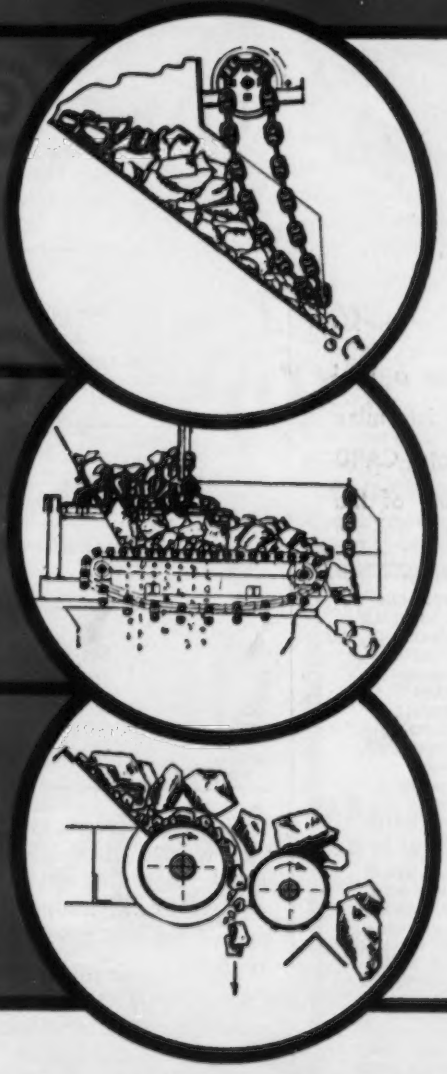
THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Texas Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Baltimore, Md. Pittsburgh, Pa. Pasadena, Calif. Houston, Texas London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

You Can't Beat An Eimco!

ROSS Material Handling Equipment



Operation Diagram of :—

ROSS CHAIN FEEDER

Completely controls the flow of any size material from storage bins and open dump chutes to crushers, conveyors, screens, etc.

Operation Diagram of :—

ROSS DROP-BAR GRIZZLY FEEDER

Every other bar drops away automatically at the discharge end, ensuring free passage for fines and presenting clear unblocked apertures to the feed.

Operation Diagram of :

ROSS TWO-ROLL GRIZZLY Separates material with extraordinary rapidity and completeness. Rear-roll surfaces are smooth. Front roll has shallow "lifting" teeth that keep the apertures permanently clear.

ROSS SCREEN & FEEDER CO.
100 QUIMBY STREET
WESTFIELD, N. J., U. S. A.

ROSS ENGINEERS LTD.
11 WALPOLE ROAD
SURBITON, SURREY, ENGLAND

Canadian Licensee: E. Long Ltd., Orillia, Ontario

The tough ones come to Card

In hard rock mining, haulage equipment takes a real beating. Three-ton boulders drop ten feet and more into mine cars with a force that dents good half-inch steel plate. CARD cars have whipped these tough conditions for many of the major ore producers of the western hemisphere.

Familiar names like these and many others dot the C. S. CARD customer lists over and over with their repeat orders. CARD cars built to order for these firms cost little more than standard stock models, yet they result in large savings because they are built to handle specific mining requirements.

CLIMAX MOLYBDENUM
INTERNATIONAL MINERALS
PHELPS DODGE
KENNECOTT COPPER
U. S. VANADIUM
U. S. POTASH
VERMONT COPPER
HOWE SOUND
CALERA MINING
HOMESTAKE
TELLURIDE MINES
IDARADO
CANANEA CONSOLIDATED COPPER CO.
ANACONDA
VICTOR CHEMICAL WORKS
CLEVELAND CLIFFS IRON
POTASH CO. OF AMERICA
CONSOLIDATED MINING & SMELTING CO. OF CANADA
AMERICAN SMELT. & REF.
UNITED STATES SMELT. REF. & MINING
UNION PACIFIC COAL
GENEVA COAL CO.
COLO. FUEL & IRON CORP.
INDEPENDENT COAL & COKE
COLO. & UTAH COAL
TUNGSTEN MINING
NEW JERSEY ZINC

CARD car engineering can do the same for you. Ask us for consultation on your outstanding haulage problem. No obligation.

C.S.Card Iron Works Co.

2501 WEST 16th AVE.,
DENVER, COLORADO

SHOP FOR YOUR SHAPE IN BEE-ZEE SCREENS

When you switch to Bee-Zee Screens you can choose exactly the shape needed to give you the results you want. That's one of the important ways Bee-Zee Screens *make you money.*

Bee-Zee Tri-Rod gives you "sharp-as-a-knife" separation when a high degree of accuracy is demanded.

Bee-Zee Round Rod holds its accuracy even when rods are worn **halfway through.**

Bee-Zee Grizzly Rod combines the best features of round and tri-rod.

Bee-Zee Grizzly Rod with protective skid rod guards against abrasive action without sacrificing efficiency or percentage of open area.

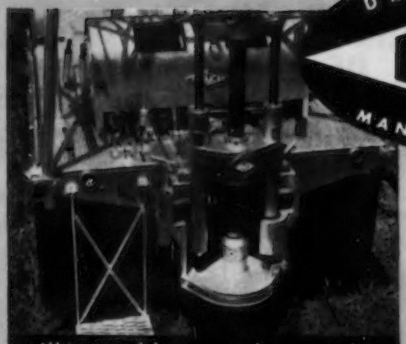
Bee-Zee Screens are precision spot-welded of stainless steel... can be fitted to any screening equipment...with supporting rods spaced for best performance.

Write, wire or phone Galesburg, Illinois, 4397 *collect.* Tell us your screening requirements... let us tell you how Bee-Zee Screens *will make you money!*

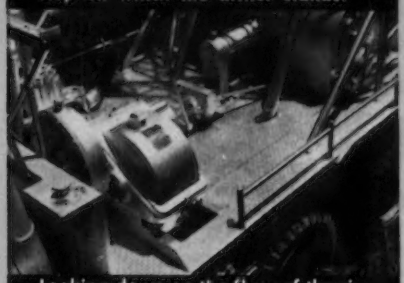
BIXBY-ZIMMER *Engineering Co.*

535 Abingdon Street, Galesburg, Illinois

DRILLING ACCESSORY
DAMCO
MANUFACTURING COMPANY INC.



Illustrated here are the controls, showing how they are grouped around the driller's station for better control of the rig. Also shown is the step on which the driller stands.



Looking down on the floor of the rig, note the flush decking and the amount of free area on the rig. This offers easier access to the pump, drive cases and drum for servicing.

From front to back, this is a modern streamlined drill rig. Mounted on the front of the truck is a Tulsa winch for utility purposes. The heavy guard is for protection when traveling through underbrush.

A DRILL RIG DESIGNED BY MEN WHO KNOW CORE DRILLING...

A background of many, many years experience in core drilling, seismograph shot hole, or water well drilling operations, often in highly remote areas, *has given DAMCO Engineers a vast knowledge of what is needed in a drill rig.* The DAMCO PORTABLE DRILL RIG has been thoroughly field tested and is recognized as one of the *FASTEST, SAFEST, SMOOTHEST, MOST TROUBLE-FREE, and ECONOMICAL DRILL RIGS available anywhere.*

This rig is designed to meet the toughest requirements, under all conditions and regardless of location. A DAMCO DRILL RIG has many outstanding and exclusive features including: the STANDARDIZING OF AIR CLUTCHES in each drum; Hydraulic Torque Converter Coupling and Transmission; uniform size for all chains, pistons, ring gears and pinions; plus numerous other money saving and time saving advantages. AVAILABLE FOR MUD, AIR DRILLING, or BOTH!

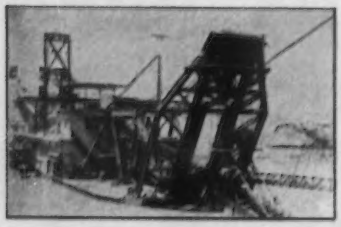
FOR COMPLETE DETAILS AND SPECIFICATIONS, WRITE FOR BULLETIN

DRILLING ACCESSORY
DAMCO
MANUFACTURING COMPANY INC.

DRILLING ACCESSORY & MANUFACTURING CO., INC.

2006 S. INDUSTRIAL • DALLAS, TEXAS

EASILY ADAPTED FOR MUSKEG TRACTOR OR SWAMP BUGGY



M-8 jig developed by YUBA for concentrating ores on dredges and in mills. It's designed to save space, reduce downtime, increase production.

FULL AREA OF

YUBA JIG BED

IS COMPLETELY ACTIVATED

YUBA jig action is positive. You set the speed and stroke wanted, get constant, even pulsations that create surface action over full area of bed. Result: YUBA M-8 jigs have a large material capacity per flow line under full control.

Any material that can be concentrated can be handled successfully in YUBA jigs, including...

CASSITERITE	RUTILE
GOLD	SCHEELITE
PLATINUM, ETC.	GARNETS
MONAZITE	SAPPHIRES
ZIRCONIUM	IRON
ILMENITE	COPPER

Design Eliminates Trouble Spots

Stainless steel hutch valves and screens prevent rusting and clogging. Rubber seal between screen grids and basket confines action to screen area. Long-wearing hutch diaphragms of reinforced synthetic rubber can be replaced easily.

"Package Drive" units for YUBA jigs are interchangeable, completely enclosed, self-lubricating. Generous use of anti-friction bearings reduces power required. Maximum frequency of a 4-cell M-8 jig is 350 at ¼". Stroke adjustments between ¼" minimum and 3" maximum are easily and quickly made, enabling you to closely control jig action.

YUBA jigs can be installed in new or old dredges or mills to supplement existing jigs or to replace other concentration methods. Send us data on ore, feed sizes and present installation if you wish us to furnish details to adapt YUBA jigs to your operation.

71

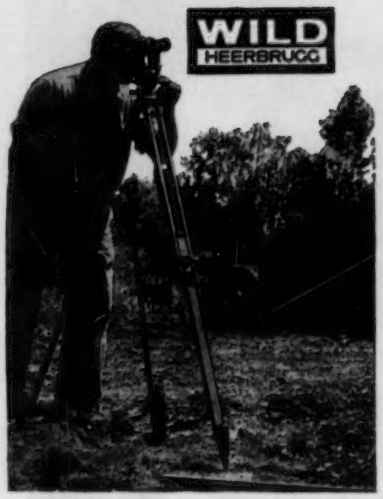
YUBA MANUFACTURING CO.

Room 706, 351 California St., San Francisco 4, California, U. S. A.

AGENTS { SIME, DARBY & CO., LTD. · SINGAPORE, KUALA LUMPUR, PENANG.
SHAW DARBY & CO., LTD., 14 & 19 LEADENHALL ST., LONDON, E. C. 3

CABLES: YUBAMAN, SAN FRANCISCO · SHAWDARBCO, LONDON

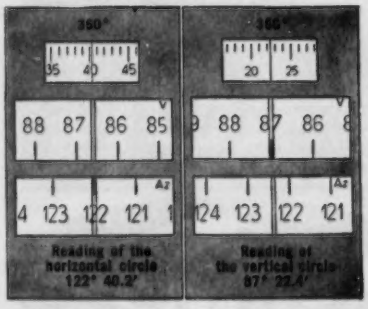
THE ACME OF ACCURACY IN ACTION



WILD T-1 OPTICAL *REPEATING* TRANSIT

Rugged, compact design... with 20 years of proven service under tough field conditions.

Both circles read from one single position through microscope alongside telescope eyepiece. Optical micrometer eliminates possibility of reading error. Illumination is provided by daylight mirror or battery attachment for night, underground or mine work.



WILD surveying instruments, inherently accurate, are Swiss precision designed for stability under adverse conditions, for sturdiness, and for ease in operation... they provide lasting trouble-free service.

●

For details phone or write for Bklt MJ3

●

Full Factory Service by Specialists

WILD HEERBRUGG INSTRUMENTS INC.

MAIN & COVERT STS., PORT WASHINGTON, N. Y.

POrt Washington 7-4843

NATIONAL IRON COMPANY'S ROCKOVER SKIP SYSTEMS . . .

National Iron Company's Rockover Skip Systems are engineered to provide inexpensive movement of bulk materials from the bottom of open pits to surface. The head frame structure is located on the surface and can be a simple unloading structure, or it can provide crushing, screening, feeding, and/or concentrating equipment.

Skip run can easily be lengthened by adding track and MOVING the Skip Loading Point to follow the mining or quarrying operations to deeper levels.

THE SURFACE STRUCTURE REMAINS STATIONARY FOR THE LIFE OF THE OPERATION.

Close up view of a 50-ton skip installation with skips in balanced operation.

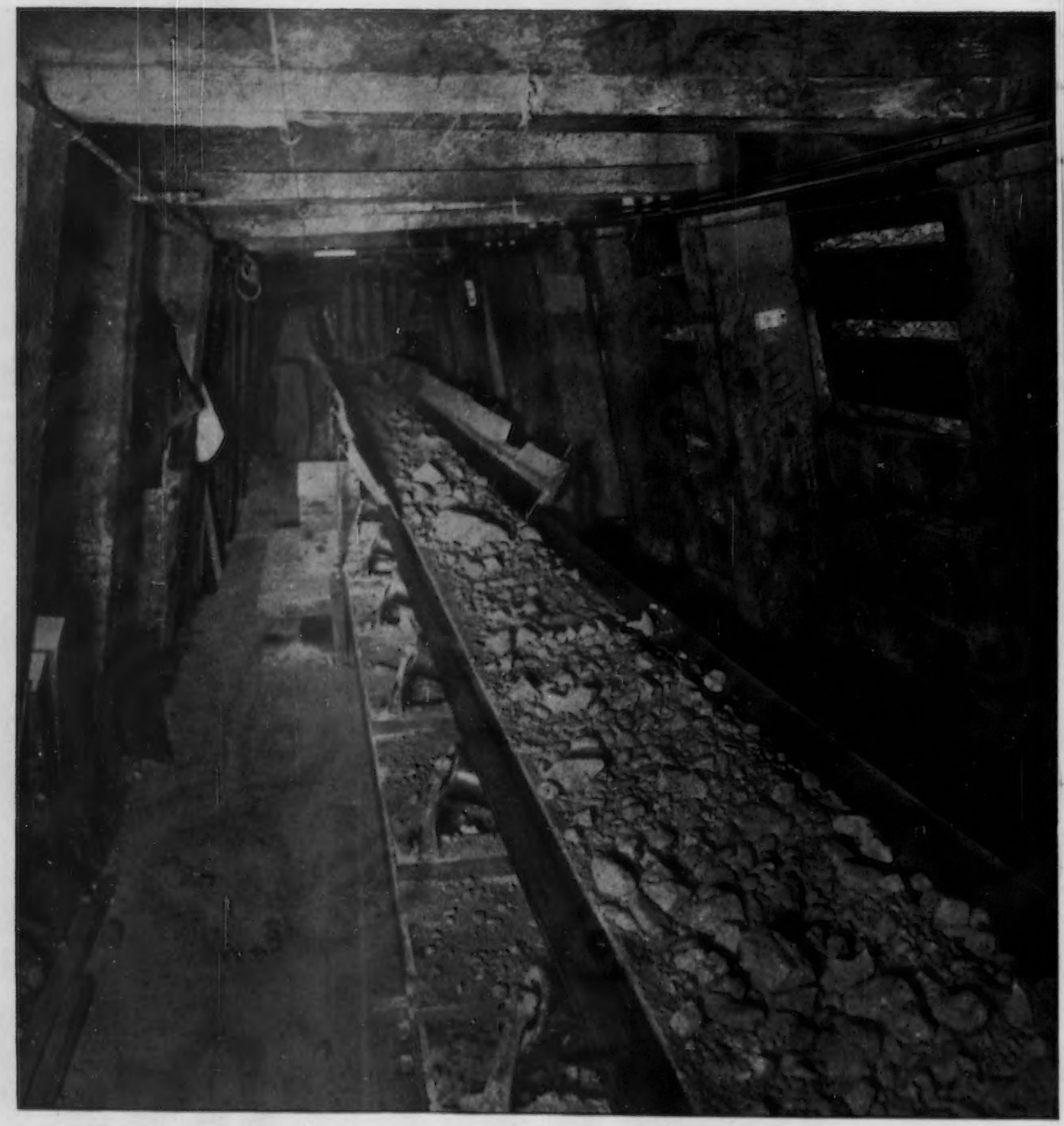
Designed to handle anything shovels and trucks will handle—no material too abrasive or blocky.

Write for booklet of operation photos.

NATIONAL IRON COMPANY

RAMSEY STREET AT 50TH AVENUE WEST MARKET 4-4863 DULUTH 7, MINNESOTA

A Complete Line of Belt



HEWITT-ROBINS

EXECUTIVE OFFICES; STAMFORD, CONNECTICUT

Conveyors to Handle Ore

Whenever you handle ore in bulk—underground, overland, in open pit or mill—Hewitt-Robins belt conveyor systems will provide the most efficient, most economical answer.

Hewitt-Robins designs and manufactures a complete line of belt conveyor systems . . . Sectionalized Ore Mine —Mine-Type Shuttle—Engineered . . . each one matched to the requirements of a particular type of ore handling operation.

All Hewitt-Robins belt conveyor systems are backed by unified responsibility. Because Hewitt-Robins is the only company that designs and manufactures *both* the belting *and* specialized machinery, and assumes full responsibility for successful operation from drafting board to installation.

ENGINEERING DATA

FOR BLOCK CAVING: Hewitt-Robins sectionalized ore mine conveyors maintain a steady flow of ore in haulage drift or sub-drift under grizzly level . . . eliminate down time for timber repairs and replacement . . . assure less chance of breaking in stopes or arching in the chutes . . . provide faster withdrawal of block being mined.

FOR UNDERGROUND HAULAGE: Hewitt-Robins sectionalized ore mine conveyors and mine-type shuttle conveyors provide continuous transportation from working face to points of beneficiation. The mine-type shuttle conveyor answers the problem of truly continuous mining . . . it follows the working face and at the same time maintains a fixed transfer point through a fixed tripper—unit is extendable or retractable up to 600' . . . Sectionalized ore mine conveyors for main and stope haulage are available in 8' and 12' sections suitable for 3' and 4' idler spacing with choice of 24", 26", 30", 36", 42" and 48" belt widths.

FOR OVERLAND, OPEN PIT AND MILL HAULAGE: Hewitt-Robins engineered conveyors are designed to meet particular local conditions. They are available in belt widths from 16" up to 72" . . . are supplied with anti-friction, offset demountable-type idlers with 2½" diam. idler rolls (where minimum vertical clearance is available) up to 7" diam. rolls (where conditions require).

Here is a partial list of

HEWITT-ROBINS PRODUCTS

that will help you cut handling costs and increase operating efficiency.

MACHINERY

- Belt Conveyors
- Belt & Bucket Elevators
- Car Shakeouts
- Conveyor Idlers
- Dewaterizers
- Mechanical Feeders
- Foundry Shakeouts
- Mine Conveyors
- Reclaiming Systems
- Screen Cloth
- Stackers & Trippers
- Vibrating Conveyors & Screens

INDUSTRIAL RUBBER PRODUCTS

BELTING:

- Conveyor
- Elevator
- Transmission

HOSE:

- Acid
- Air & Air Drill
- Barge Loading
- Dust Suction
- Fire
- Fuel Oil & Gasoline
- Gasoline Pump
- Mud Pump Suction
- Oil Suction & Discharge
- Propane-Butane
- Road Builders'
- Rotary Drilling
- Sand Blast
- Sand Suction
- Sea Loading
- Servall®, All-Service
- Steam
- Tank Car & Tank Truck
- Vacuum & Air Brake
- Water & Water Suction
- Welding, Twin-Weld®

•

For information and service on industrial rubber products, contact your Hewitt-Robins Industrial Supply Distributor. Through his complete stock of Hewitt-Robins Rubber products, and his familiarity with local field conditions, he can fill your supply needs promptly and correctly. See Classified Phone Book for the Hewitt-Robins Industrial Supply Distributor serving your area.

1444

INCORPORATED

DOMESTIC DIVISIONS: Hewitt Rubber • Robins Conveyors • Robins Engineers • Restfoam
FOREIGN SUBSIDIARIES: Hewitt-Robins (Canada) Ltd., Montreal • Hewitt-Robins Internationale, Paris, France • Robins Conveyors (S. A.) Ltd., Johannesburg • **EXPORT DEPARTMENT:** New York City.

KEYS TO ADEQUATE LUBRICATION—Wherever you see the sign of Farval—the valve manifolds and dual lubricant lines—you know a machine will be properly lubricated. Pictured is the Farval-lubricated frame of a Bucyrus-Erie Model 150-B 6-cubic-yard power shovel.

Now—mine shovels work longer at less cost with Farval lubrication

SHOVEL bearings take terrific jolting in pit mining service. Unless they are properly lubricated at all times, you're in for shutdowns, lost time and repair bills. That's why it pays to install Farval Centralized Systems on quarry and mine shovels.

FARVAL is the foolproof Dualine system of centralized lubrication that delivers a measured amount of clean lubricant at regular intervals to every bearing. From a central station, lubricant is pumped under pressure to a measuring valve at each bearing, delivering the exact amount of lubricant required. Grit, abrasive sand or dust that may have penetrated bearings is forced out by lubricant pressure, and the lubricant forms a protective seal. Possible bearing failure due to hit-and-miss hand oiling is eliminated. Shovels work better and longer.

On this Bucyrus-Erie 150-B, for example, Farval takes only a minute or two to lubricate every bearing needing protection. Compare this to the time lost on a shovel that has to shut down for 15 to 20 minutes every time the operator needs to lubricate by hand! Another point—Farval saves up to 3 of every 4 pounds of lubricant used by other methods.

FREE LUBRICATION SURVEY

Let us send one of our lubrication engineers to inspect your heavy equipment. Without obligation, he will present a written analysis of what Farval can do for you. Write for Bulletin 26 for the complete Farval story.

The Farval Corporation

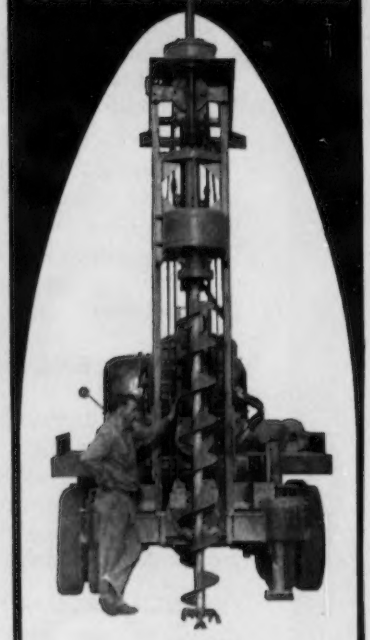
3281 EAST 80th STREET • CLEVELAND 4, OHIO

Farval is an affiliate of The Cleveland Worm & Gear Co., Represented in Canada by Peacock Brothers, Limited

NEW HEAVY-DUTY McCARTHY DRILL

HEAVY RUGGED POWERFUL

FOR A WIDE VARIETY OF USES



This new heavy-duty drill, Model 106-24, is used for blast hole drilling, general exploration, foundation drilling, dewatering operations, deep post holes, etc., and is a companion drill to McCarthy 106-8 using 8" dia. augers and smaller. Has high-speed power take-off—one speed for rock, one speed for other earth formations. Outside power take-off for large augers at one-half speed. Hydraulically operated throttle valve.

AUGER DIAMETER		DEPTH OF BORE
20 INCHES		30 FEET
16 "		40-60 "
12 "		60-80 "
8 "	and under	100 "

8" diameter auger bores through shale and sandrock. Larger diameter auger bores through shale and hardpan formations. The choice of contractors where the going is tough.

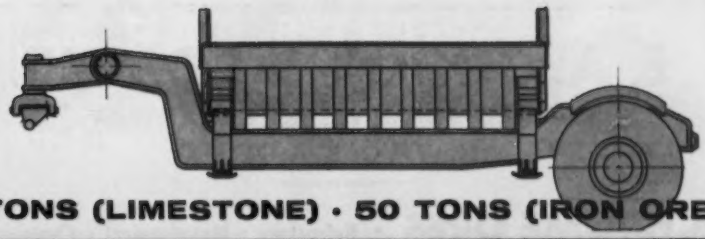
For complete information contact The Salem Tool Co.

THE SALEM TOOL CO.

803 S. ELLSWORTH AVE.

SALEM, OHIO • U. S. A.

Coming!



NEW EASTON TP 36 TONS (LIMESTONE) • 50 TONS (IRON ORE)

New all-welded TP-2736 nears completion. View shows box-section body cradles and double-acting hinges.

Dependable overhead dumping is essential. Above: Easton standard package overhead electric dumping system—job-proved in hundreds of mines and quarries ...*exclusive* with Easton.

Bigger Payloads!

IN PRODUCTION at Easton...the first TP-2736 fleet...the most exciting forward-looking development in a decade of automotive transportation in mines and quarries. Here you have, for the first time, the job-proved dependability of Easton's cost-busting *doorless* pan in an all-new, low-frame trailer, rated at 36 tons limestone (Model TP-2736), 50 tons iron ore (Model TP-2750). Smart planning for 1955-60 calls for bigger payloads than ever before...at lower cost! Get the facts now on the great new Easton TP trailers, in capacities from 10 to 50 tons.

NOW is the time to modernize your hauling. Order now for early deliveries.

EASTON®

B-1067

EASTON CAR & CONSTRUCTION COMPANY • EASTON, PA.

E. A. GODOY & CO., INC.

CUNARD BUILDING, 25 BROADWAY
NEW YORK 4, N. Y.

CHROME ORES • Refractory • Metallurgical • Chemical
MANGANESE ORES • Metallurgical • Chemical
IRON ORES • Open hearth • Blast furnace

Release this button pusher for productive labor . . .

with the NOW PROVEN STAMLER AUTOMATIC LOADING STATION

Load your cars from belt or elevator *AUTOMATICALLY* without manual attendants.

The Stamler all hydraulic automatic loading station in combination with the STAMLER HYDRAULIC CAR SPOTTER will perform completely unattended all operations necessary for maximum loading of your cars uniformly without spillage.

Stamler all hydraulic features eliminate possibility of failure due to faulty contacts, or the accumulation of coal dust or moisture. Virtually no maintenance or supervision is necessary.

Reorders from SATISFIED CUSTOMERS PROVE ITS VALUE IN REDUCING COSTS.

—ALSO NEW—

The Stamler "Shortie" Car Spotter.

It's only 6 feet longer than your mine car.
This new unit incorporates all Stamler exclusive features.

W. R. STAMLER CO.

PARIS, KENTUCKY

Schroeder Bros., Exclusive Eastern Sales Agent, Pittsburgh, Pa.
Union Industrial Corporation, Carlsbad, New Mexico.

THE OUTSTANDING MINE VENTILATION LINE

Outstanding
- ✓ FOR QUALITY
- ✓ FOR DEPENDABILITY
- ✓ FOR COMPLETENESS

ABC BRATTICE CLOTH

7 types to fit all needs—3 types of jute cloth, 2 types of cotton, plastic and Black Ace for non-gaseous mines. Carefully processed to resist flame, except Black Ace, and to resist mildew. In widths and lengths for any seam.

MineVent

FLEXIBLE VENTILATION TUBING

Made in two grades; jute base and cotton base, synthetic rubber coated. Resists leakage, abrasion and moisture. Available in 9 diameters, 8" to 36" and 25, 50 or 100 ft. lengths. Choice of 3 types of suspension, demountable patented Snap-On coupling or Sewed-In coupling. Most widely used mine ventilation tubing.

NEOLON FLEXIBLE VENTILATION TUBING

The new Neoprene coated Nylon fabric tubing. Almost impossible to tear. Airtight. Resistant to abrasion, acid mine water and flexing. Same lengths and diameters as MineVent.

NON-COLLAPSIBLE TUBING

Both MineVent and Neolon are available with telescoping spring wire inserts rendering the tubing non-collapsible. Light weight. Economical.

ABC INFLATABLE BRATTICE

Sizes to fit any opening. Readily fills rough contours, jagged walls, etc. Quickly inflated by special hand pump. Quickly deflated to move to new location. Easy to transport. Economical to use.

ABC POWDER BAGS

Rubber coated durable fabric, firmly sewed, for long use and hard wear. 5 sizes: 20, 36, 60, 125 and 160 sticks of explosive.

Send for Catalog 55.

AMERICAN BRATTICE CLOTH CORP.

220 So. Buffalo St., Warsaw, Indiana

Use USS Lorain Rolled Plate Linings

to reduce mill "downtime" and cut grinding costs

● One of the biggest robbers of your grinding profits is probably "downtime" for repairs and replacements necessitated by plate failure or bolt breakage. You can lessen costly downtime in your mills by using USS Lorain Rolled Plate Linings. These rugged *rolled steel* plates give extra long service compared to ordinary castings. And they are interchangeable . . . heat treating compensates for localized wear. The special-composition, heat-treated bolts are virtually break-proof and last the long life of the plates.

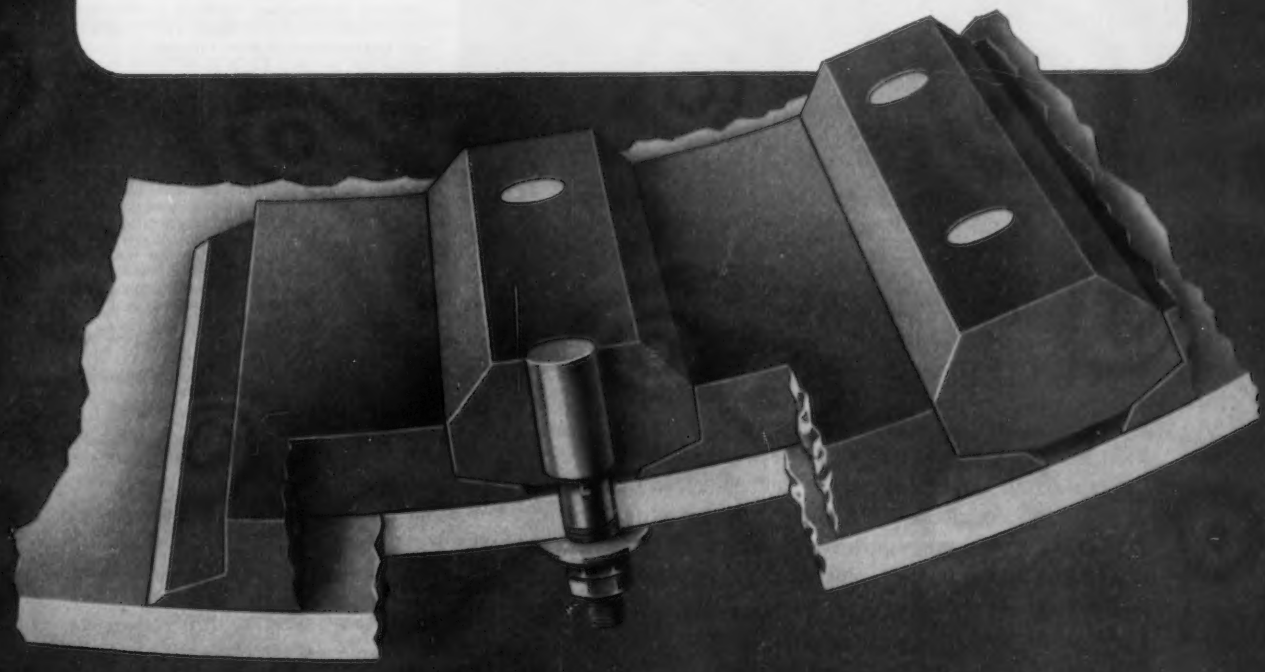
When you use USS Lorain Rolled Plate Linings you get closer tolerances between plates and between plates and lift bars, giving you a tighter overall lining. This means no more shell wash and allied troubles that can ruin the mill itself.

Not only is frequency of replacement reduced with USS Lorain Linings, but the time involved in the actual replacing is less, because these plates are accurately made to size . . . they go in easily, quickly.

Protect your grinding profits. Write to us today for the names of leading mill manufacturers who can supply you with USS Lorain Rolled Plate Linings—for wet or dry grinding.

USS Grinding Balls are designed for economical grinding too. Continual quality checks throughout their production assures you of balls that will take long, rough wear evenly. Sizes from ¾" to 5".

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS LORAIN ROLLED PLATE LININGS *and* USS GRINDING BALLS

USS

UNITED STATES STEEL

MAN-MADE WEATHER UNDERGROUND

In mining service, there's nothing more vital than a dependable method for supplying fresh air and eliminating stale air, gases, fumes and dusts. That's where Naylor lightweight pipe comes in, providing today's outstanding system for push-pull ventilation. Its lightweight makes it easy to handle and install, particularly with the Naylor one-piece Wedge-Lock coupling to speed connection. Extra collapse strength and safety are assured through Naylor's exclusive lockseamed spiralwelded structure which permits the use of lighter gauge steel without sacrificing strength. For full details on this distinctive pipe and coupling combination, write for Bulletins No. 507 and No. 514.

NAYLOR PIPE

Naylor Pipe Company • 1243 East 92nd Street, Chicago 19, Illinois
Eastern U.S. and Foreign Sales Office: 350 Madison Avenue, New York 17, New York

Want to slash operating costs... get more tons per man-shift . . . and higher total tonnage?

Switch to

LONG PIGGYBACK® CONVEYOR Continuous Haulage Mining

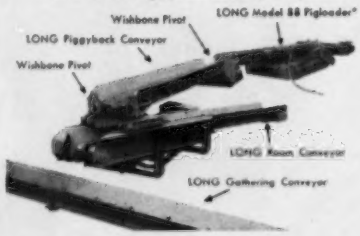
The Piggyback Conveyor system provides uninterrupted haulage from the face . . . eliminates costly loading delays common with "stop-and-go" transportation of other systems.

Every day more and more companies are learning that Piggyback Conveyor mining pays off in greatly increased production at greatly reduced operating costs. In fact, at many mines, this unique system has meant the difference between operating at a profit instead of a loss.

With proved, practical Piggyback Conveyor mining, material is loaded and moved out in a steady, continuous flow—with no down time waiting for intermittent transportation. The result: more tons per man—higher total tonnages. What's more, capital investment per ton for installing the Piggyback Conveyor system is much lower than for any other continuous mining method. Want complete details? Write us today—there's no obligation.

*Trade Mark

Units of the Piggyback Conveyor System



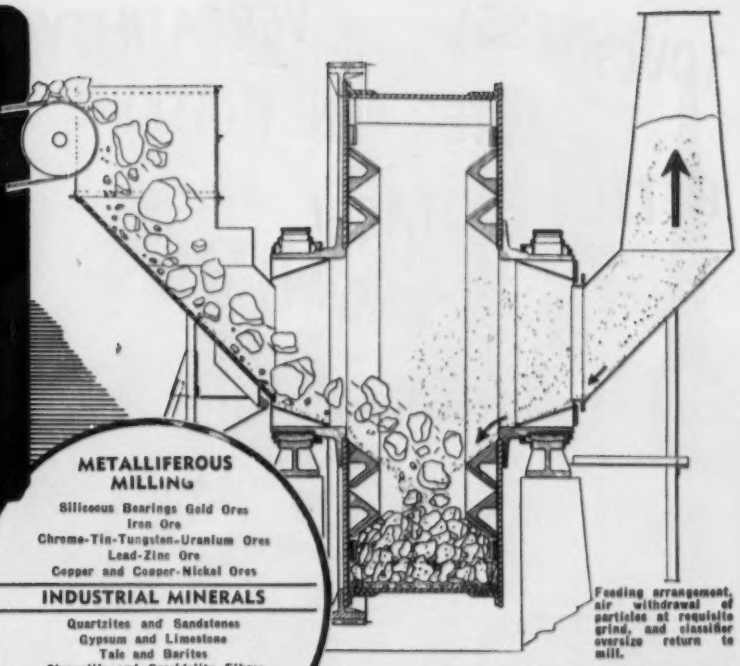
The receiving end of the Piggyback Conveyor is attached to the Pigloader Loading Machine and follows it as it moves. Thus, the operator can devote his full attention to loading. Wishbone pivots make possible continuous haulage at 90° angle breakthroughs.

For complete details or a demonstration, write us today!

The LONG Company
OAK HILL W. VA.

Here is the

METALLURGICAL and COST DATA on the new "AEROFALL" MILL



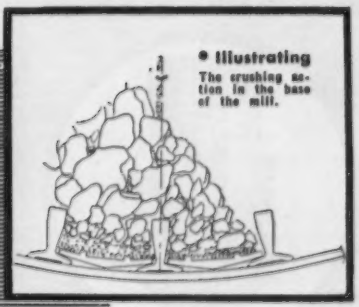
METALLIFEROUS MILLING

Siliceous Bearings Gold Ores
Iron Ore
Chrome-Tin-Tungsten-Uranium Ores
Lead-Zinc Ore
Copper and Copper-Nickel Ores

INDUSTRIAL MINERALS

Quartzites and Sandstones
Gypsum and Limestone
Talc and Barites
Chrysotile and Crocidolite Fibres
Ferrosilicon
Various Types Pot Lining
Feldspars
Artificial Abrasives

The Aerofall Mill is a dry, combined crushing-grinding unit, capable of taking run-of-mine minus 18" size material and reducing it in a single operation to as fine as 99.0% minus 325 mesh. For a coarse grind, it will produce a product in the 6 mesh range. It will tolerate a moisture content of 3½ to 4% without affecting either capacity or product, and up to 25% moisture by dual treatment.



● Illustrating
The crushing action in the base of the mill.

GREATER SAVINGS WITH THE NEW AEROFALL MILL CIRCUIT

Here is a comparison of AEROFALL MILL CIRCUIT versus current standard circuit of uranium ores.

The current standard circuit normally consists of two or three stage crushing, followed by two stage grinding.

The AEROFALL MILL CIRCUIT consists of an AEROFALL MILL with or without a PRIMARY CRUSHER.

GREATER SAVINGS RESULT FROM
1. LOWER LABOUR COSTS.
2. LOWER STEEL CONSUMPTION, LINERS, RODS AND BALLS.
3. LOWER POWER COSTS.
4. LOWER REAGENT COSTS IN LEACHING CIRCUITS.
5. FILTERING and THICKENING ONLY ONCE IN THE CIRCUIT.

Savings on THE AEROFALL MILL CIRCUIT represent a minimum of .75¢ per ton on a 1000-ton per day circuit uranium operation.

In the Aerofall Mill, the material itself is normally the total charge. This mill uniquely combines the comminution action of (1) abrasion, (2) blow impact, and (3) drag. Product is collected in either wet or dry type cyclone.

The Aerofall Mill produces not only a more uniform grind, but will also give, when required, a "differential grind" — meaning that minerals can be handled with minimum of breaking down of their individual crystals, thus resulting in outstanding improvements in metallurgical results. The above drawings illustrate the design of the Aerofall Mill, showing its various actions and why there is a minimum of "slip", with maximum energy devoted to actual comminution at high speed, making for increased operating economies, as shown in the above illustration. In short, the Aerofall Mill represents, in results and in low costs, a revolutionary development in general milling practice, and merits your further careful investigation.

Complete data sent on request

AEROFALL MILLS, LTD.

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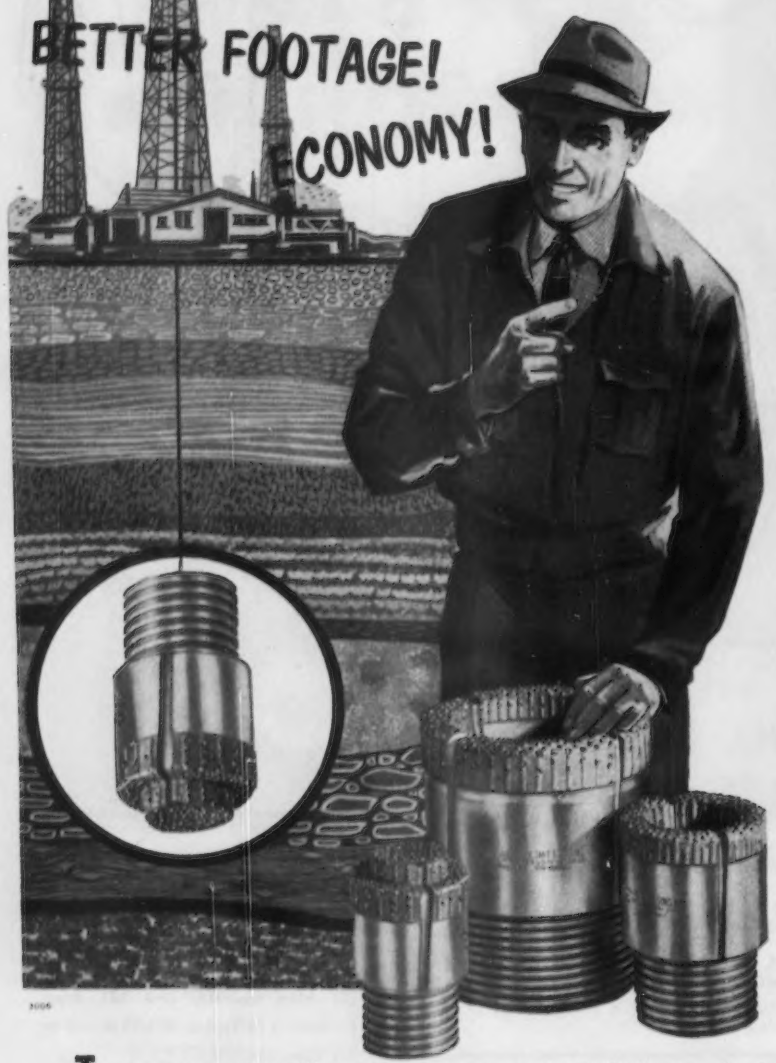

These are terms that JKS engineers are concerned with 24 hours a day in the design and manufacture of Diamond Drill Bits that suit your coring and drilling qualifications to a "T".

Throughout years of steady progress these standards were the basis for the drilling bits that are now recognized as unbeatable the world over.

HARDHED matrix for non-abrasive formations
HARDHED 40 matrix for average drilling conditions
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When you next need a diamond drill bit which no formation will slow up, gives full core recovery, faster penetration *AND* saves you *days* and *dollars* in coring and drilling, contact your nearest J. K. Smit field representative or write us direct for literature and assistance.

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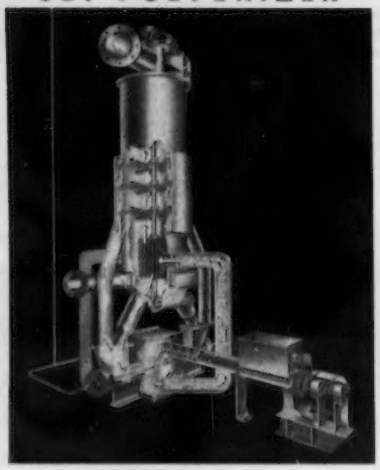
LOW MAINTENANCE HIGH EFFICIENCY

WITH THE MAJAC JET PULVERIZER



When necessary the Majac Jet will pulverize to a fineness impossible by any other means. In addition, you can *control* that fineness accurately to any desired degree . . . or provide for various percentages of different micron sizes.

Operating by steam, gas or compressed air, the Jet keeps maintenance costs at a minimum. At the same time it provides fast, efficient pulverization of a wide range of materials. If pulverizing is on your program, find out about the Majac Jet.

Some materials which have been pulverized successfully by the Majac Jet:

Alumina	Graphite	Mica
Ceramic Frit	Gypsum	Perlite
Cement	Iron Ore	Silica Sand
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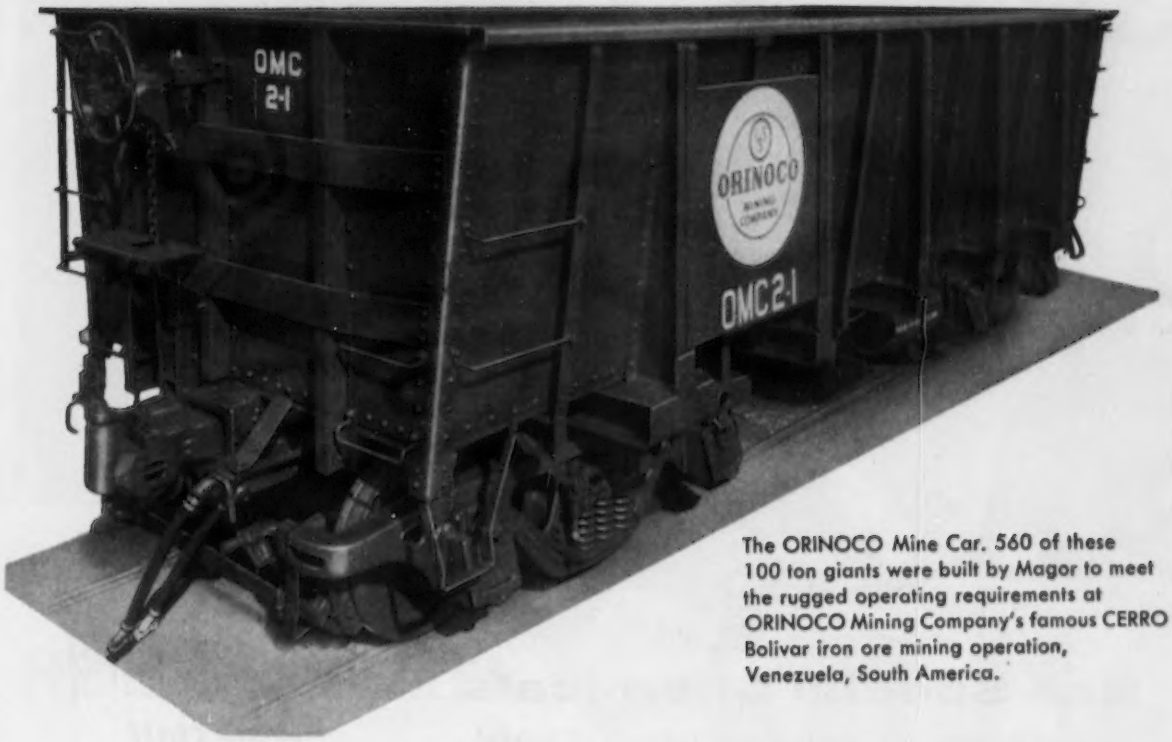

The ORINOCO Mine Car. 560 of these 100 ton giants were built by Magor to meet the rugged operating requirements at ORINOCO Mining Company's famous CERRO Bolivar iron ore mining operation, Venezuela, South America.

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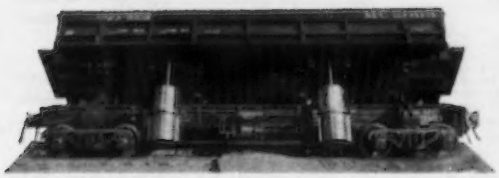

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Carrier Natural-Frequency Conveyors substitute the *natural resonant action of coil springs* for brute force. These amazing conveyors require only a very small motor to vibrate the pans in the natural frequency of the springs.

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If brute force conveyors are robbing you of valuable production time and profits, get *all* the facts from Carrier Conveyor Corporation, 2170 Frankfort Avenue, Louisville 6, Ky.

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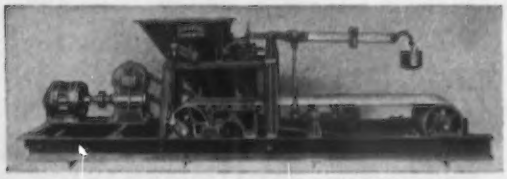
SIZE		MAXIMUM CAPACITY*		Maximum Size of Cubes	Available With Motor Operated Gate
Belt Width	Length Scale Platform	Light Duty	Heavy Duty		
6″	2′ 0″	2 Tons		Finely ground	No
10″	2′ 6″	5 Tons		Finely ground	No
	4′ 6″ & 6′ 0″		12 Tons	Finely ground	No
14″	2′ 6″	8 Tons		¼″ Cubes	No
	4′ 6″ & 6′ 0″		24 Tons	½″ Cubes	No
20″	2′ 6″	15 Tons		1½″ Cubes	No
	4′ 6″ & 6′ 0″		60 Tons	1½″ Cubes	Yes
30″	4′ 6″ & 6′ 0″		158 Tons	3 ″ Cubes	Yes
36″	4′ 6″ & 6′ 0″		220 Tons	4 ″ Cubes	Yes
48″	4′ 6″ & 6′ 0″		300 Tons	4½″ Cubes	Yes

*Figured on material weighing 100 lbs. per cubic foot. Amount shown is capacity per hour.



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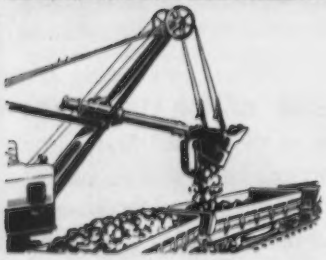

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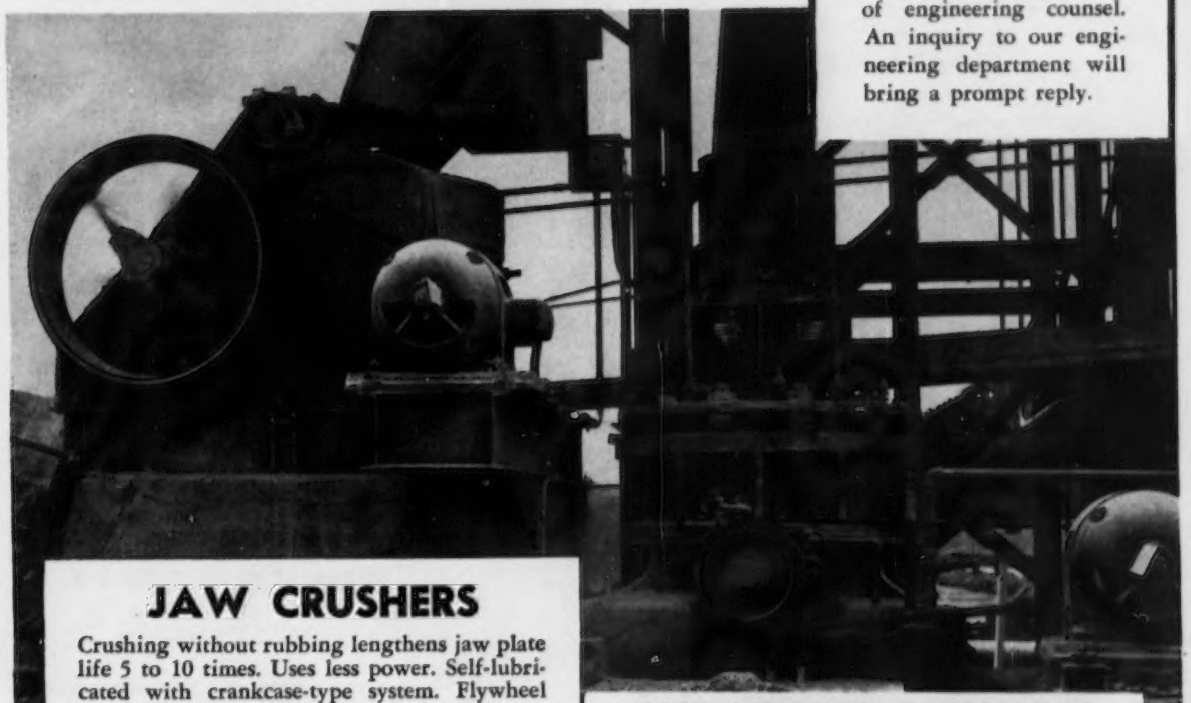

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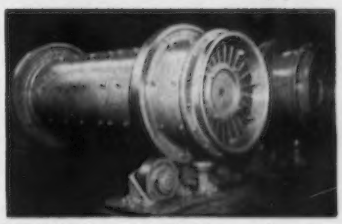
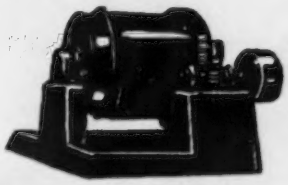
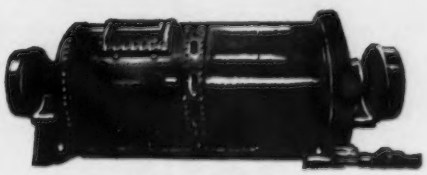


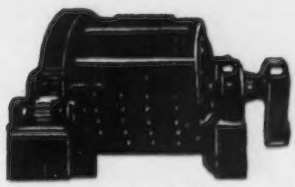
Special open end Rib Cone mills rubber lined for light regrinding of dredge concentrates.



Screening mill for amalgamating and concentrating classes of ores. Capacity—2 to 95 tons per 24 hrs.



Peripheral discharge mill for producing granular product. For controlled grinding of tungsten and similar ores where sliming must be eliminated.



Grate discharge mill. Also available in plain overflow, screening and convertible types with capacities from 25 to 500 tons per 24 hrs.

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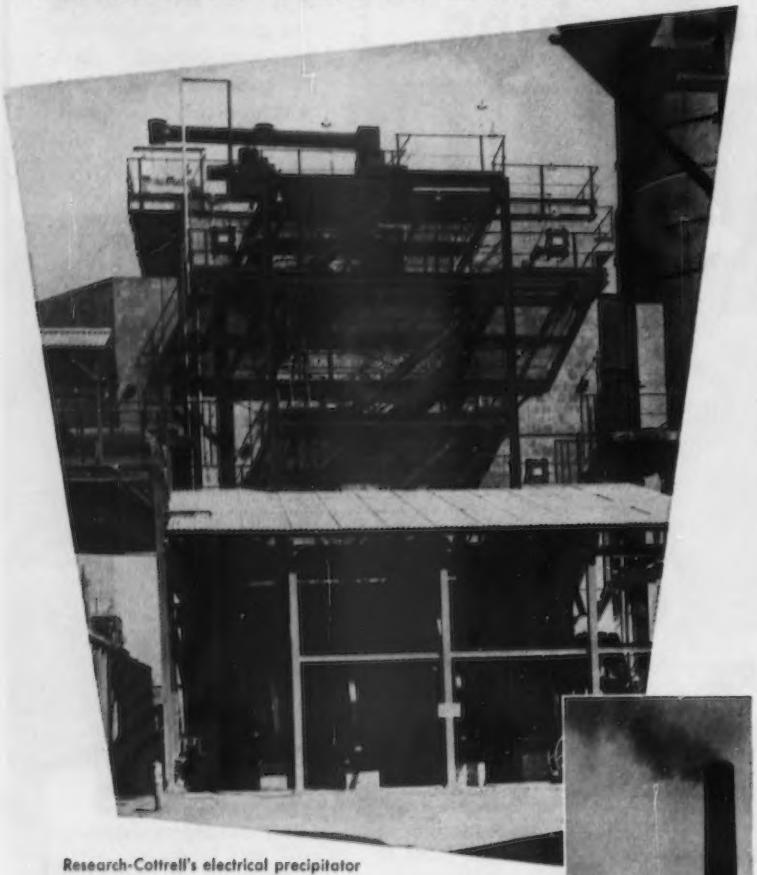
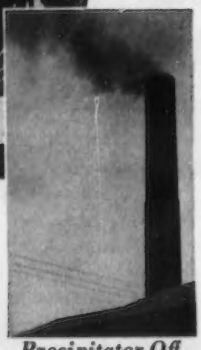


Research-Cottrell's electrical precipitator installation at the Palmerton, Pa. plant.



Precipitator Off

Precipitator On

The two photographs (right) show the results of this Research-Cottrell installation. The smoke in the picture at the top (Precipitator Off) consists of dry dust and fume entrained in the zinc ore sintering machine gases.

The picture at the bottom (Precipitator On) shows nothing but water vapor escaping from the same stack.

If you have a fume problem that involves recovering valuable materials that are going up the stack or combating a smoke nuisance, get in touch with your nearest Research-Cottrell representative. His experience with over 300 roaster and metallurgical precipitators will enable him to advise you on the most effective—and economical solution to your problem.

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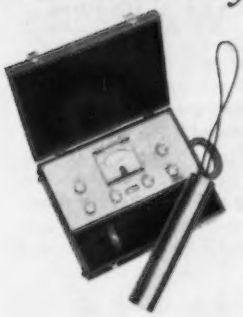

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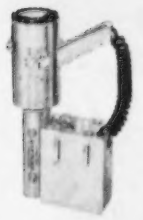
SPECIFICATIONS

Ranges	.01, .025, .05, .1, .25, 1 MR/HR
Sensitivity	Gamma
Size	13" x 17" x 5"
Weight	25 lbs.
Shipping weight	45 lbs.
Price complete, ready to use	$1995.00

MODEL 111B *"Deluxe Scintillator"** AEC #SBX11A



Portable scintillation counter. Many times more sensitive than geiger counters. Lightweight, simple to operate. Detects at depths of a few feet to a few hundred feet depending on conditions. Primarily for URANIUM detection. Shockproof, waterproof, tropicalized.

SPECIFICATIONS:

Probe size	3¾" x 13½"
Probe weight	3¾ lbs.
Battery box size	3" x 4½" x 5½"
Box weight	4 lbs.
Ranges	.025, .05, .5, 2.5, and 5 MR/HR
Shipping weight	13 lbs.
Price complete	$495.00

MODEL 115 *"Super Scintillator"** AEC #SPX11B

A deluxe version of the Model 111, the 115 may be used for airborne or motor vehicle surveys. Can be used with Recorder. Primarily for URANIUM detection.

SPECIFICATIONS

Carrying case size	5" x 11" x 14½"
Weight of complete instrument	16 lbs.
Shipping weight	26 lbs.
Price complete	$595.00

MODEL 120 *"Drill Hole Geiger Counter"*

A super sensitive Geiger Counter that has been especially designed for making radioactive measurements in drill holes as deep as 1000 feet. It can also be used for surface URANIUM prospecting. Comes with one probe for drill holes and one for surface exploration.

Price complete Including a 50 ft. cable	$289.50
Additional cable per ft.	.25

MODEL 117 *"Special Scintillator"**

A highly sensitive Scintillation Counter at a moderate price. An ideal field instrument because of its ruggedness, compactness and light weight. Industrial, Laboratory, or Uranium use.

SPECIFICATIONS

Ranges	.025, .05, .25, .5, 2.5 and 5 MR/HR
Sensitivity	Gamma
Size	4½" x 7¼" x 7"
Weight	6¾ lbs.
Shipping weight	10½ lbs.
Price complete	$299.50

MODEL 107 *"Professional Geiger Counter"*

AEC #SGM49B

A Geiger Counter of the highest sensitivity, accuracy and stability. Has external probe. The best Geiger Counter made for field work. For use in Uranium detection, Civil Defense and Laboratory.

SPECIFICATIONS

Size approx.	3½" x 4½" x 6½"
Weight approx.	6 lbs.
Sensitivity	Beta, Gamma
Ranges	20, 2, and .2 MR/HR
Shipping weight	8 lbs.
Price complete	$139.50

MODEL 106 *"Lucky Strike Geiger Counter"*

AEC #SGM49A

A Geiger Counter designed for field prospecting under rugged conditions. High sensitivity makes it possible to detect even small deposits of URANIUM and to estimate the quality and quantity of ore in the field. Lightweight, compact, and weatherproof.

SPECIFICATIONS

Size approx.	3½" x 4½" x 6½"
Weight approx.	5 lbs.
Sensitivity	Beta, Gamma
Ranges	20, 2, and .2 MR/HR
Shipping weight	7 lbs.
Price complete	$99.50

MODEL 108 *"Snooper"*

Sensitive as some of the larger Geiger Counters, the 108 fits easily in hip pocket or pack. Requires no experience to operate. Comes complete with earphones, ore sample and instruction booklet.

SPECIFICATIONS

Size approx.	1½" x 3" x 5"
Weight approx.	1¼ lbs.
Shipping weight	2 lbs.
Price complete	$29.95

*REG. U. S. PAT. OFF.

The instruments listed above do not locate metals. Send direct for information on our complete line of metal ore and metal object locators.

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PRECISION RADIATION INSTRUMENTS, INC.

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WORLD'S LARGEST MANUFACTURER OF PORTABLE RADIATION INSTRUMENTS

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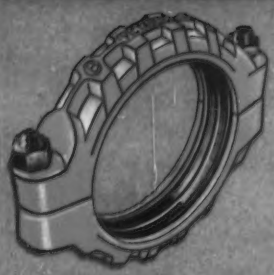


VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install—sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light duty applications. Sizes 2", 3", 4". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

VICTAULIC FULL-FLOW FITTINGS

Complete line of Elbows, Tees, Reducers, Laterals, etc.—to fit all Victaulic Couplings. Streamlined for top efficiency, easy to install. Sizes ¾" to 12".

VIC-GROOVER TOOLS

Handy, on-the-job grooving tools that do the work in half the time. Light weight, easy to handle—operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

ROUST-A-BOUT COUPLINGS

Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 8".

VICTAULIC SNAP-JOINTS

Victaulic's new boltless, speed coupling. — Style 78 — hinged into one assembly. Hand-locks for time and dollar savings. Sizes 1", 1¼", 2", 3", 4".

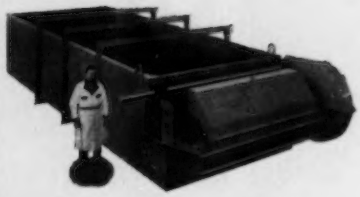
EASIEST WAY TO MAKE ENDS MEET

Promptly available from distributor stocks coast-to-coast. Write for NEW Victaulic Catalog-Manual 55-31.

VICTAULIC COMPANY OF AMERICA

P. O. Box 509 • Elizabeth, N. J.

It's NEW! It's BIG!



EAGLE 48" LOG WASHER

Handles material up to 8" in diameter . . . capacity to 150 tons per hour (depending upon material size and amount of foreign matter to be removed). Tub is 9'4" wide x 24' or 30' long. Both logs are 48" dia. Sturdy Tubular log shaft . . . no deflection. Enclosed gearing at discharge end as shown. A heavy duty money maker that will economically abrade and scrub ore, crushed stone or gravel . . . year after year.

Send for Catalog 55.

EAGLE IRON WORKS

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Screw Washers · Log Washers · "Swintek" Dredge Ladders

Breaker Balls, Pile Hammers, and Line Weights.

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MANUFACTURERS OF PORTABLE STATIONARY AIR COMPRESSORS AND CONSTRUCTION TOOLS

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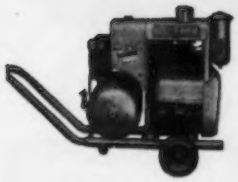
Sales Offices and Representatives in all Principal Cities

MODELS 20 and 35



Gasoline engine driven compressors, with push button electric starting, delivering respectively 20 and 35 c.f.m. @ 100 p.s.i. are useful for general maintenance, painting, tire service, digging, backfilling, pressuring lubricating equipment. Also available skidded for use in pickup truck.

½ to 5 h.p. STATIONARY

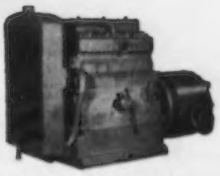
Electric motor driven compressors for shop use, base mounted or on receiver—½ to 5 h.p. V belt drive only, 7½ to 15 h.p. V belt or direct drive—start and stop or continuous operation with unloading.

MODELS 75 and 125

Two wheel mounted 75 and 125 c.f.m. gasoline engine driven compressors will operate hand held rock drills or light wagon drills, furnish air for forges and furnaces and be generally useful around a mine. Also available skidded.

INDUSTRIAL COMPRESSORS

Vertical, water cooled compressors, 20 to 150 h.p., running water or radiator cooling—operate efficiently in hot or cold places—V belt or direct motor drive—all types of mountings.



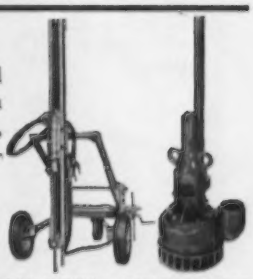
UNISTAGE MODELS 125 to 600

125, 210 and 315 c.f.m. sizes available with either gasoline or diesel engine, 600 c.f.m. diesel only. For continuous service at 40-125 p.s.i.g. and intermittent service to 200 p.s.i.g. Pneumastat makes the amount of air produced fit the job. The most economical compressors for the big jobs.

PNEUMATRACTOR

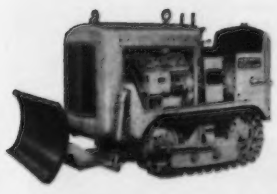
Self-propelled 125 c.f.m. gasoline engine driven air compressor—does anything a wheel tractor will do—mounts 1 yard loader, 7′ bulldozer blade, backhoe, winches, etc. A universal piece of equipment.

20, 45 and 55 pound class hand held drills and wagon drills with 45, 55 and 126 pound (4″) drifters, and sump pumps 370 g.p.m. maximum capacity.



ROCK DRILL **WAGON DRILL** **SUMP PUMP**

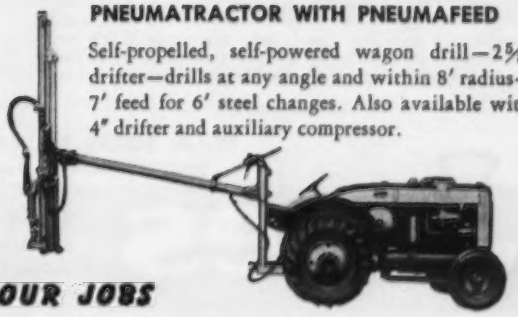
MODEL 60 CRAWLER



A self-propelled 60 c.f.m. gasoline engine driven air compressor on tracks—will go anywhere, easily maneuvered, can mount hydraulically controlled blade or ¼ yard bucket, or winch.

PNEUMATRACTOR WITH PNEUMAFEED

Self-propelled, self-powered wagon drill—2⅝″ drifter—drills at any angle and within 8′ radius—7′ feed for 6′ steel changes. Also available with 4″ drifter and auxiliary compressor.



SCHRAMMAIR YOUR JOBS

4 . . . ways to cut costs and assure peak production

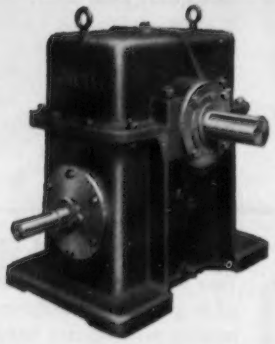
1 Jones Herringbone Gear Drives are built for endurance where long life under severe service conditions is essential. This NEWEST and most COMPLETE line offers:

ECONOMICAL FIRST COST—more sizes and ratios to choose from means a drive that really fits.

LOW COST OPERATION—97% to 99% efficient—large roller bearings throughout—conservatively designed for long, trouble-free service.

BETTER MATERIALS—alloy iron housings—alloy steel gearing—all pinions integral with their shafts.

Catalog No. 100 has complete application data.

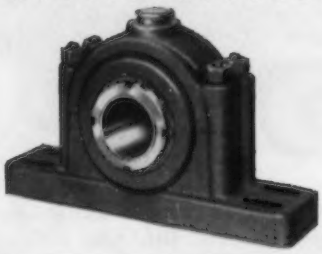


2 Jones Worm Gear Drives are designed to provide the utmost in dependability for continuous operation on heavy-duty applications. Space saving right angle units are available in horizontal types with the worm above or below the gear or vertical types having the output shaft extend upward, downward or both. Standard ratios up to 80 to 1, capacities up to 100 horsepower. Cost-reducing performance is assured by these features:

- hardened and ground worms
- large roller bearings throughout
- large oil reservoir
- precision generated gears
- rigid, well ribbed housings
- simple, reliable lubrication

Complete information upon request.

3 Jones has the facilities for producing herringbone, helical, worm, spur, bevel or mitre cut tooth gears made from high-test cast iron, steel, bronze or non-metallic materials, in any quantity, exactly to your specifications. *If you have a gear problem, it will pay you to take advantage of the more than 60 years industry-wide application experience acquired by Jones. Your inquiry will receive prompt attention.*



4 Jones heavy-duty Pillow Blocks, Timken Roller Bearing equipped, have been tried, tested and proven in Heavy Industry. Only Jones Pillow Blocks have *all* these features to give the advantages of better, more satisfactory service, longer trouble-free operation and lower operating and maintenance costs.

- double row Timken bearings
- full length tapered sleeve
- self-alignment external to bearings
- steel labyrinth seals
- ball and socket self-alignment
- interchangeable bearing units

Ask for Catalog No. 500

W. A. JONES FOUNDRY & MACHINE CO.
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Better Drives . . . Since 1890

Jones

HERRINGBONE—WORM—HELICAL—GEAR SPEED REDUCERS
CAST IRON PULLEYS • CUT GEARS • V-BELT SHEAVES
ANTI-FRICTION PILLOW BLOCKS • FLEXIBLE COUPLINGS

Install Norblo

to be sure you have worry-free 'round the clock

Automatic Dust Collection

Automatic bag cleaning

No down time

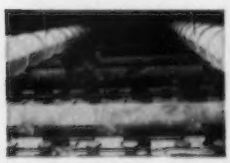
Low, easy maintenance

Norblo builds its own blowers in a wide range of capacities.

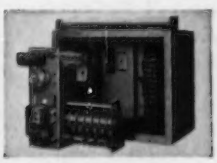
Norblo also builds centrifugal and hydraulic dust collectors, exhaust fans, cement air cooling systems, and portable type dust collectors.

You can have continuous dust and fume collection at full rated capacity without a worry about maintenance down time. Norblo automatic bag type dust arresters handle heavy loads by faithfully maintaining a constant suction drop across the arrester. Compressed air shakers coupled with air reversal action assure efficient bag cleaning, one compartment at a time.

Norblo engineers the complete installation with ample capacity for your needs, with wide adjustability and all the safeguards you may need. Few moving parts combined with a fully coordinated functional design result in very high efficiency, low cost of operation and maintenance. It will pay you to have Norblo engineers study your requirements. Write for Bulletin 164-4.



Each group of 39 bags has its individual compressed air shaker.



The Norblo Variable Electronic Timer governs the shaking and cleaning cycle.

Any compartment may be cut out of the operation and inspected through access door.

The Northern Blower Company

Engineered Dust Collection Systems for All Industries

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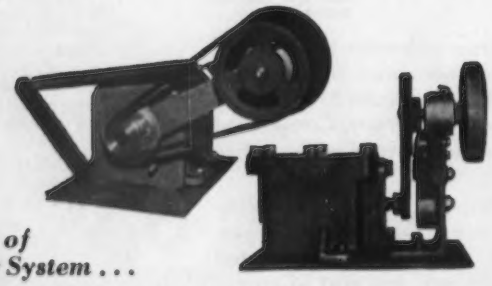
ENSIGN CENTRIFUGAL SWITCHES



The Watchdog of Your Conveyor System . . .

Ensign Centrifugal Switches for belt conveyors provide belt protection and sequence operation of multiple conveyors including shaker or chain conveyors feeding onto belt conveyors. Bulletin 1100 Centrifugal Switch, left above, has dust-tight enclosure. Bulletin 1101, right above, has explosion-tested enclosure.

Request Ensign Bulletin 1100 (dust-tight) or 1101 (explosion-tested)

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914 Adams Avenue, Huntington 4, W. Va.

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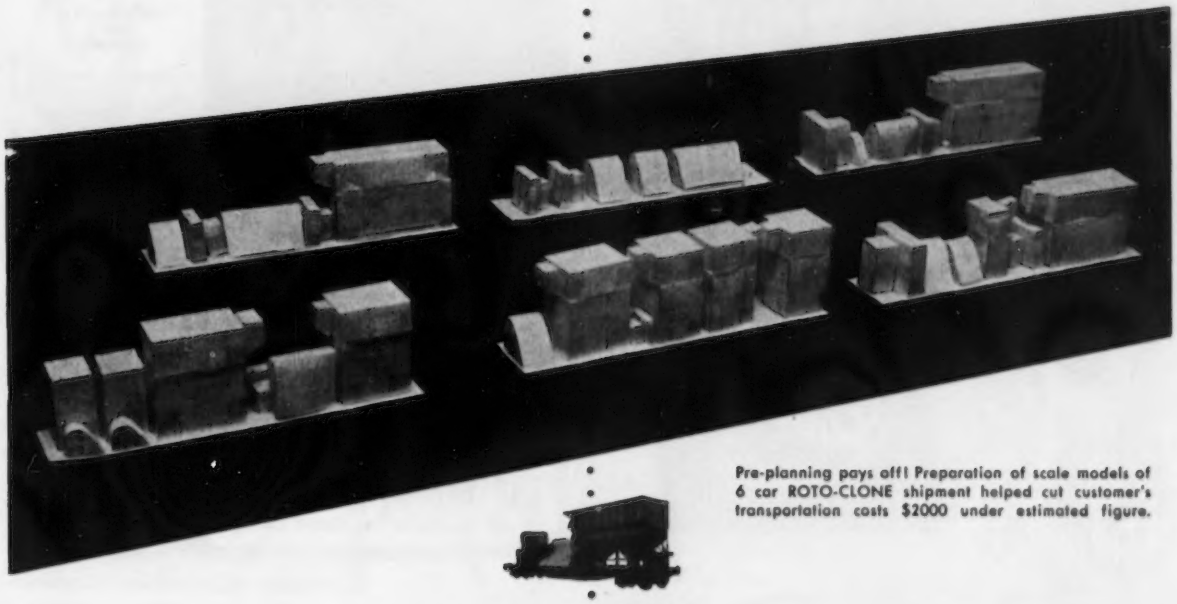
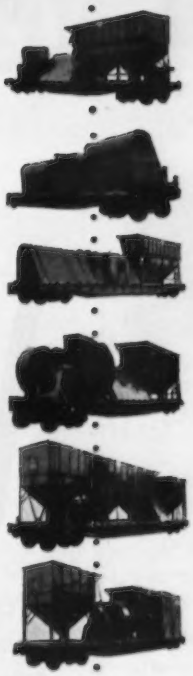
6 CARLOADS of ROTO-CLONES to Solve 1 Plant's DUST PROBLEMS



Pre-planning pays off! Preparation of scale models of 6 car ROTO-CLONE shipment helped cut customer's transportation costs $2000 under estimated figure.



HOW important is dust control in today's concept of a modern ore processing plant? Here's one prominent copper company's answer—and it adds up to six carloads of AAF Dust Control Equipment.

The twelve Type N ROTO-CLONES in the shipment will provide 220,000 cfm of control for crushers, screens, bins and belt transfer points. These AAF wet-type collectors will provide a combination of important results—highest efficiency in the collection of fine dust particles; elimination of abrasion and collection of dust as a sludge which makes for easy disposal and elimination of a secondary dust problem.

Why this emphasis on dust control? Clean plant interiors cut maintenance costs; make for better employee relations. And, as for community relations, you can be certain that ROTO-CLONES* will contribute much to this company's acceptance as a "good neighbor".

AAF's interest in your dust problems is not based on size. Whether the operation requires equipment in carload or LCL lots—involves capacities of 600 or 600,000 cfm—you'll receive the benefits of top engineering service and proven product design.

So, if you have a dust problem, let's get at it. Just call your nearby AAF representative or write us direct.

**ROTO-CLONE is the trade-mark (Reg. U.S. Pat. Off.) of the American Air Filter Company, Inc., for various dust collectors of the dynamic precipitator and hydro-static precipitator types.*

AAF herman nelson

American Air Filter

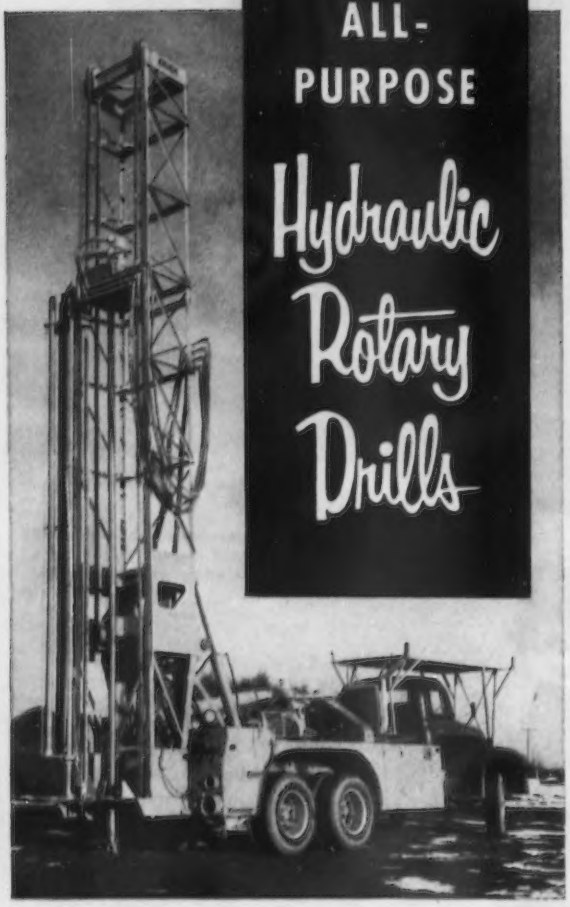
COMPANY, INC.

American Air Filter of Canada, Ltd., Montreal, P.Q. • 193 Central Avenue, Louisville 8, Kentucky

Reich

ALL-PURPOSE

Hydraulic Rotary Drills



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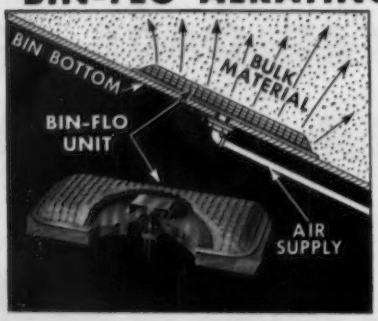
BIN-FLO AERATING UNIT

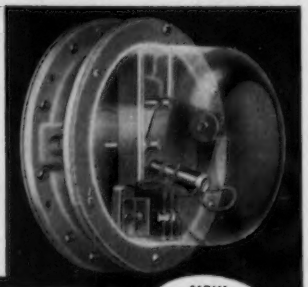


Provides Steady Flow of Dry, Finely Ground Materials which tend to bridge in storage. Uses only small amount low-pressure air.

BIN-DICATOR BIN LEVEL INDICATOR

For All Bulk Materials

signals change in level; automatically starts and stops filling and emptying equipment.



THE BIN-DICATOR CO.
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mining engineers

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2151 Lawrence Street Denver 2, Colorado
Over 50,000 Brunton Transits since 1896

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Why WORM gear?

Cutaway shows compact interior design and construction of a typical Cleveland worm gear speed reducer.

Why CLEVELAND?

HERE are some of the inside reasons why Cleveland worm gear speed reducers are specified by many of the leading builders and users of industrial machinery.

• **SAFE, SPACE-SAVING, RIGHT-ANGLE DRIVE**—Clevelands are compact, provide a wide range of reduction speeds. Worm and gear enclosed in sealed housing replace dangerous open gearing, belts and pulleys. Safety always for machine operators and lube men! Gearing runs in oil bath, insures positive lubrication, eliminates oil cans and grease paddles.

• **SMOOTH TORQUE FLOW**—By virtue of the sliding action of worm on gear, a Cleveland transmits power uniformly and smoothly. Constant angular velocity assures positive control of work on driven machine.

• **LONG-LIFE EFFICIENCY**—Experience demonstrates that Cleveland case-hardened worms and nickel-bronze gears actually improve with use. Even operating under continued, severe overloads, danger of sudden failure is remote. Thousands of Clevelands operate for the life of driven machines.

Get the complete Cleveland story by writing for new Catalog 400 today. The Cleveland Worm & Gear Company, 3281 East 80th Street, Cleveland 4, Ohio.

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Worm Gear
Speed Reducers

American Smelting and Refining Company

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Garfield, Utah
El Paso, Texas
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Copper Refineries

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Zinc Smelters

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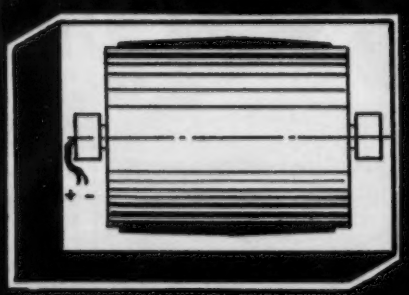
Contact local management or:

Ore Purchasing Department, 120 Broadway, New York 5, N. Y., U. S. A.

You be the judge.....

THE P.P.T. (Power Packaged Terminal)
CONTAINS WITHIN THE PULLEY ITSELF,

- THE MOTOR
- SPEED REDUCTION UNIT
- HOLD BACK (when needed)



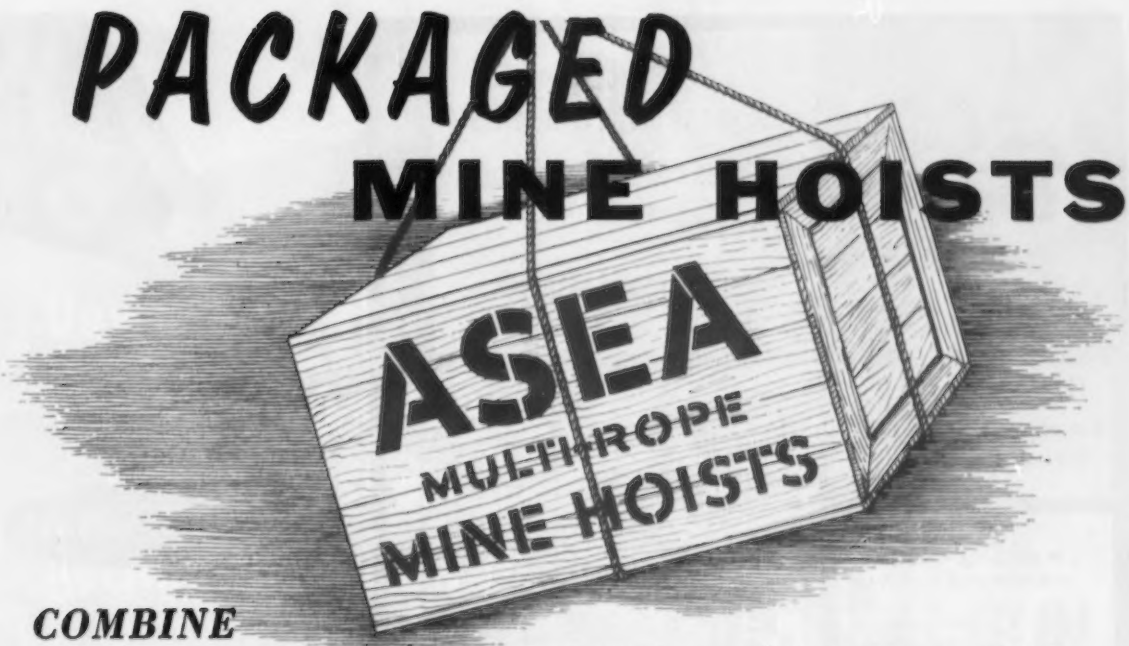
SMALL WONDER THAT MORE AND MORE
OPERATORS NOW USE THIS MIRACLE PULLEY! P.P.T. (MOTORIZED CONVEYOR HEAD PULLEY)

TO 60" BELT WIDTH • AC or DC • TO 50 HORSEPOWER

CHRISTIAN

J.D. CHRISTIAN ENGINEERS • 480 POTRERO AVE. • SAN FRANCISCO, 10

PACKAGED MINE HOISTS



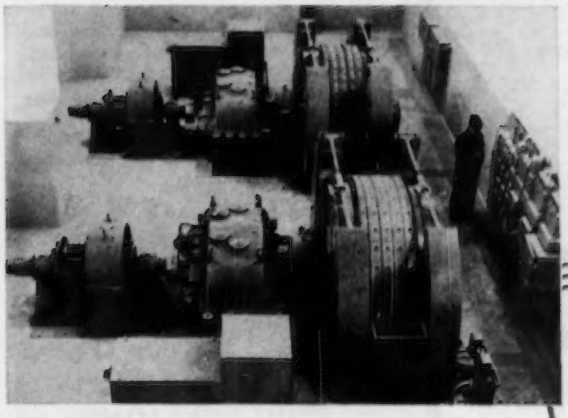
COMBINE
all mechanical and electrical equipment into one, complete, factory-assembled and guaranteed hoisting plant package.

COMBINE **unique *safety* of operation, due to load-dividing parallel ropes, positive protection against damage from over-winds, and patented electric speed guards with *flexibility* through fingertip "switch-over" choice between fully automatic, push-button, or manual control for hoisting from any one of a number of levels.**

COMBINE **hoisting *capacity* up to the largest yet to be installed in any mine with *small space requirements*—small enough to allow hoists to be installed in headframes.**

COMBINE ***saving in first costs*** **of hoisting equipment, foundations, lifting facilities, hoist housings and headframes with *reduction in operational costs* due to less rope wear, lower power demand, fewer or no operators and less maintenance.**

These two ASEA mine hoists with four parallel ropes are among those mounted above the shaft



Take advantage of ASEA's 20 years of experience in developing these complete hoist installations. Let us send you our introductory bulletin with more information about the ASEA hoists, or if you have any plans for new hoisting facilities let us talk them over with you.

COUPON

AROS ELECTRIC, INC.
16 East 71 Street, New York 21, N. Y.
Please send me your free introductory bulletin on the ASEA multi-rope mine hoists.

Name_____
Company_____
Address_____ State_____
City_____

AROS ELECTRIC, INC.
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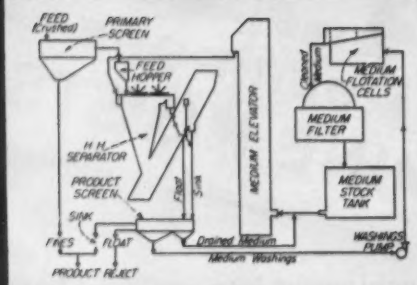
HH SINK AND FLOAT PROCESS

- increases metal recoveries
- reduces concentration costs
- saves man hours
- increases metal reserves

Look at the advantages of the wide utility HH Sink Float Process. Pre-engineered. Pre-fabricated.

- *ability to make closer separation on difficult feeds*
- *positive control of separation density*
- *positive removal of float product*
- *positive removal of sink product*
- *less power required for operation*
- *ability to treat coarser sizes*
- *easier to start after shut-down*
- *easy to run . . . any mill operator can run it*
- *low first cost per ton treated*
- *rejects coarse waste without grinding it*
- *produces coarse market concentrate*
- *permits non-selective mining*
- *treats metallics as well as non-metallics*
- *treats mine ores, dumps, fill, development ore*
- *serves existing and new installations*



The H.H. Sink Float Process has proved its wide utility in the treatment of many millions of tons of ores during the last 14 years.

Because H.H. Sink Float plants are pre-engineered and pre-fabricated, they save time in construction, at a lower cost.

This proven process can work to your advantage. Your inquiry will receive the immediate attention of our technical experts.

Write today for more information.

SINK FLOAT
H H SINK FLOAT PROCESS

The Sink & Float Division

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How to keep informed on the "with what" part of your business

AT YOUR FINGER TIPS, issue after issue, is one of your richest veins of job information—advertising. You might call it the "with what" type—which dovetails the "how" of the editorial pages. Easy to read, talking your language, geared specifically to the betterment of your business, this is the kind of practical data which may well help you do a job quicker, better—save your company money.

Each advertiser is obviously doing his level best to give you helpful information. By showing, through the advertising pages, how his product or service can benefit *you* and *your* company, he is taking *his* most efficient way toward a sale.

Add up all the advertisers and you've got a gold mine of current, on-the-job information. Yours for the reading are a wealth of data and facts on the very latest in products, services, tools . . . product developments, materials, processes, methods.

You, too, have a big stake in the advertising pages. Read them regularly, carefully to keep job-informed on the "with what" part of your business.

McGRAW-HILL PUBLICATIONS

Down went the overhanging rocks ...and the cost of getting them down!

REMINGTON INDUSTRIAL GUN Cuts $85.00 job to $9.50 at quarry

"It used to cost us about $85 each time we had to remove overhanging rocks from our quarry—now with a Remington Industrial Gun we do the whole job for $9.50." That's the report from a zinc mine in Alabama.

Savings like this are common. The Remington Industrial Gun saves hours of hazardous work . . . can be aimed, loaded and fired in seconds. Mount it on a truck, a tripod or a mobile chassis. Set it up in any part of your mine or quarry. You'll find real versatility in this fast, safe way of removing obstructions. The U.S. Bureau of Mines, for example, has used it for dislodging large icicles at distances *up to 200 yards!*

BEST WAY TO REMOVE KILN RINGS, TOO. A few well-placed shots with the Remington Industrial Gun loosen rings, cause them to fall when kiln is rotated. Minimum downtime! Big gains in production!

REMINGTON INDUSTRIAL SHELLS have tremendous smashing power. They're loaded with a powerful 3-ounce lead projectile that develops 7,475 foot-pounds' muzzle energy.

---SEND COUPON FOR FREE FOLDER---

Industrial Sales Division E.M.J.-3
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Please send me your free folder describing the Remington Industrial Gun.

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*City*_____ *State*_____

"If it's Remington—It's Right!"

Remington DUPONT

How this giant crusher changed an industry

● Here's the giant of them all . . . the world's first 4248 overhead eccentric jaw crusher . . . the new PIONEER powerhouse that changed an industry!

Big, tough jobs such as turnpike construction demand *tremendous production* of crushed stone *at the lowest possible cost!* No equipment could completely fill this demand until PIONEER introduced this new 4248 crushing giant. And in filling the demand, it changed the thinking and production methods of the industry.

Big Production With 3 Big Savings

Production demands are much more easily met when you have this crusher on the job. For example, a PIONEER 4248 on the West Virginia Turnpike job crushed rock at the almost unbelievable rate of 700 tons per hour with 100 per cent crushing and a jaw setting of only 7 inches!

But it does a lot more than meet record-breaking production schedules. It results in *three big savings.* It saves the difference in cost between it and expensive *multiple* crushers; it saves drilling and blasting costs because it takes rock up to 40" x 46" in size; and it saves quarry-loading costs because fewer and larger loading machines can be used.

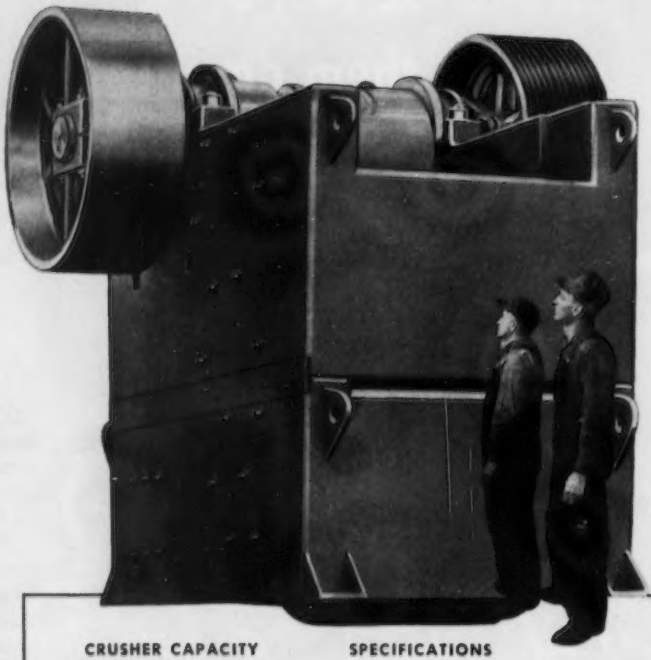
Why Maintenance Costs Are Low

Features which reduce maintenance and down time: box-type, all-welded steel base which gives added strength with over-all reduced weight . . . jaw plates cast of tough manganese steel and designed to absorb cold flow and peening . . . split jaw plates which are reversible for double wear . . . self-aligning anti-friction bearings, precision fit for smooth and lasting performance . . . inner and outer eccentric shaft bearings mounted closer together than on any other anti-friction bearing crushers to lessen shaft strain.

In those cases when maintenance or repair *is* needed, oil pressure expands inner bearing races so bearings slide easily on the shaft if you wish to inspect or remove them. A hydraulic ram holds pitman arm forward when you need to replace toggle plates. Split flywheel hubs make removal and installation simple. You can quickly reverse jaw plates without special tools.

Ask your crusher salesman these questions:

1. Are bearing housings saddle-mounted to assure constant alignment?
2. Is it possible to remove bearings hydraulically?
3. How closely spaced are inner and outer bearings?
4. Can jaw setting be adjusted by hydraulic means?
5. Can toggle plates be changed with hydraulic assist?
6. Are flywheels provided with split hubs for easy removal?
7. Is crusher made with split base for easy installation?
8. Does crusher have 2 tension rods?



CRUSHER CAPACITY

Field operations indicate that for each inch of jaw opening, capacity increases approximately 100 tph. This rate is with a relatively high crushing percentage. In field installations, production has reached 700 tph with 7" setting.

SPECIFICATIONS

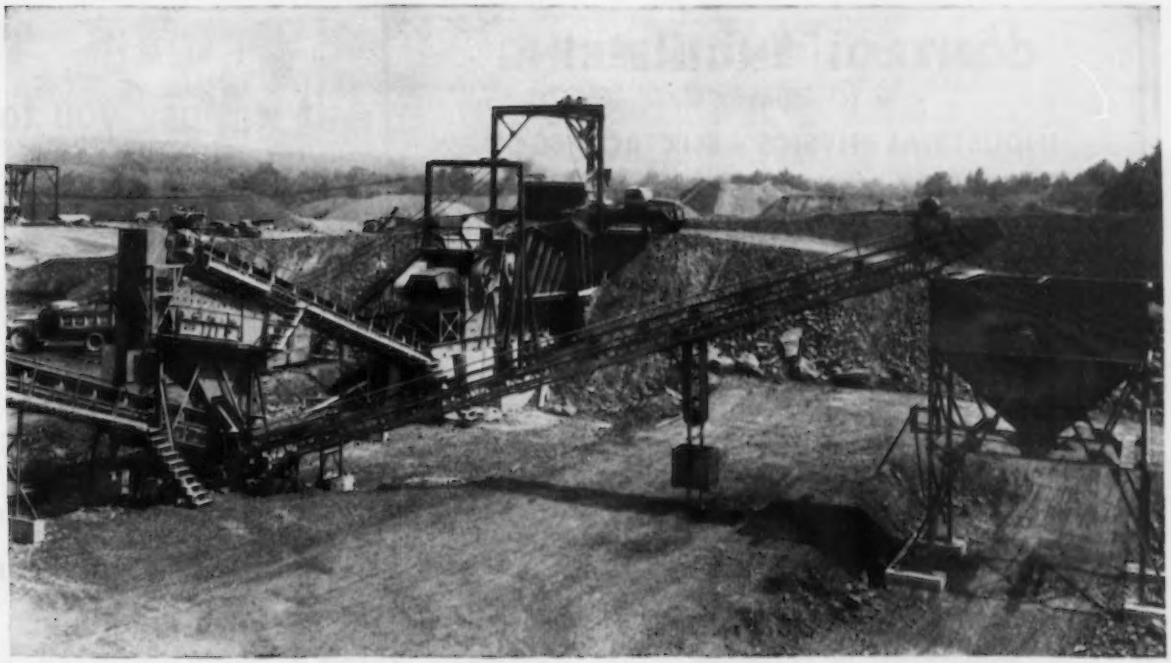
Jaw opening	42"
Width of jaws	48"
Range of setting	5"-12"
Over-all depth, moving jaw	104"
Over-all depth, stationary jaw	90"
Weight (approximate)	94,200 lbs.
HP required	180-210

PIONEER ENGINEERS WORK HAND IN HAND WITH YOU

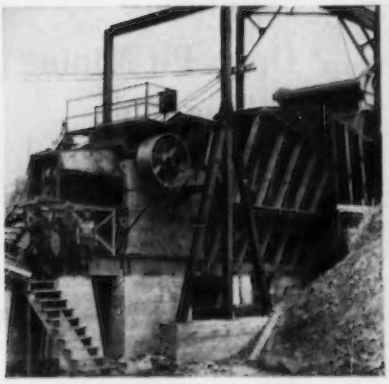
In Tyler Breslin Quarry's high producing PIONEER Turnpike Plant (shown at left), output of the 4248 Jaw Crusher often exceeded 700 tph with 7" jaw setting.

This plant also illustrates the factory-distributor-owner teamwork for which PIONEER is so famous. First, the Distributor analyzed requirements and sent the data to PIONEER's Engineering Department which prepared complete erection prints. Then an experienced PIONEER engineer was sent to supervise installation of the plant.

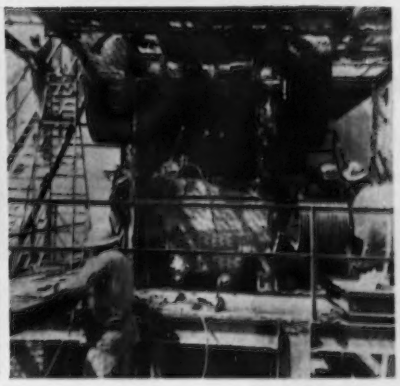
But PIONEER's responsibility didn't end then. Its alert Distributor Service Organization and factory-trained maintenance men are always on call whenever quick service is needed.



In this installation the primary plant feeds a system producing six different sizes of rock and sand. Heart of the system is a PIONEER 174 Primary which has a 48" x 16' PIONEER ORO Feeder and a PIONEER 4248 Jaw Crusher. The feeder is constructed of ⅜" thick cast manganese steel pans with integrally cast links, which withstand the huge loads dumped by quarry trucks. It correctly positions large, odd-shaped rocks before they enter the crushing chamber of the 4248 Jaw Crusher. It also controls the amount and rate of feed to the crusher so that maximum output is reached and maintained.



Workmen are dwarfed by PIONEER's 4248 Jaw Crusher. Designed to reduce blasting and drilling costs, and to turn out enormous tonnages, this 95,000 lb. giant is owned by General Crushed Stone Co. of Easton, Pa.



This PIONEER 4248 Jaw Crusher is part of the Apex plant of U. S. Lime Products Co., Las Vegas, Nevada. Note hydraulic mechanisms for holding pitman forward when adjusting crusher setting or changing toggle plates.

PIONEER assembles 4248 Jaw Crusher. Here you see the 19,000 lb. pitman arm with the 5200 pound shaft assembly being lowered into the 4 cu. yd. crushing chamber. Length of moving jaw is 104", stationary jaw 90".

For further details write Pioneer Engineering Works, Inc., Minneapolis, Minnesota (subsidiary of Poor & Company, Chicago) or your nearest PIONEER distributor.

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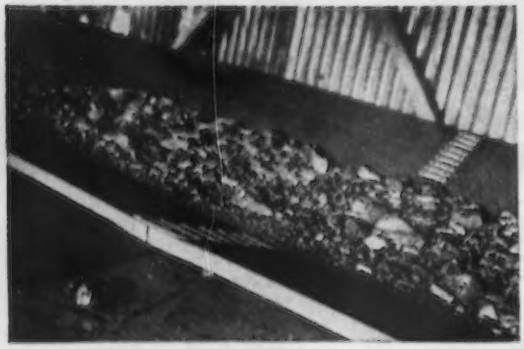

FOR HEAVY CONVEYOR AND ELEVATOR BELTS OF ANY WIDTH

★ FLEXCO Fasteners make tight butt joints of great strength and durability.
★ Trough naturally, operate smoothly through take-up pulleys.
★ Distribute pull or tension uniformly.
★ Made of Steel, Monel, Stainless, Everdur. Also Promal top plates.
★ FLEXCO Rip Plates are for bridging soft spots and FLEXCO Fasteners for patching or joining clean straight rips.

Compression Grip distributes strain over whole plate area

Order From Your Supply House. Ask for Bulletin F-100

FLEXIBLE STEEL LACING CO., 4635 Lexington St., Chicago 44, Ill.

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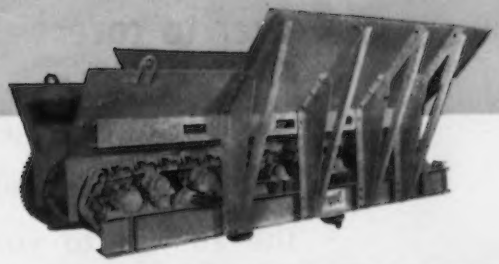
When buying, or requesting product information, please be sure to mention ENGINEERING AND MINING JOURNAL Mining Guidebook and Buying Directory issue.

Cedarapids
Built by IOWA

HEAVY-DUTY EQUIPMENT FOR CUTTING PROCESSING COSTS

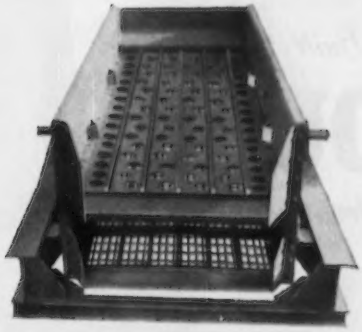
Cedarapids equipment is engineered with all the features essential to low-cost ore handling. Each unit is built for the *extra strength* necessary for heavy-duty service in the world's most rugged industry. Each unit is designed by experts in the field for *high capacity* production. The "proved-in-service" *low maintenance* costs of Cedarapids equipment is another bonus feature that helps you cut processing costs. Investigate Cedarapids advantages today!



HEAVY-DUTY APRON FEEDERS

ASSURE SMOOTH, WORKABLE FLOW OF ORE

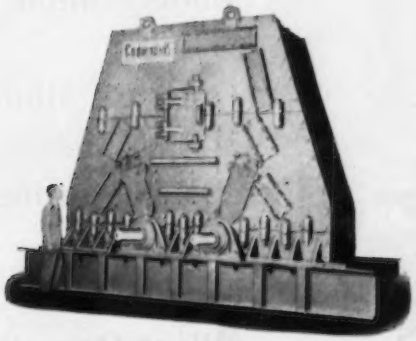
This big 40" x 12'4½" Apron Feeder is especially designed for smooth feeding of heavy, large-size material. Rugged construction, with 9 shafts beneath the heavy cast steel flights, withstands the dumping of heavy loads into the feeder.



HEAVY-DUTY SCALPING SCREENS

COMBINE BIG-VOLUME PRODUCTION WITH LOW MAINTENANCE COSTS

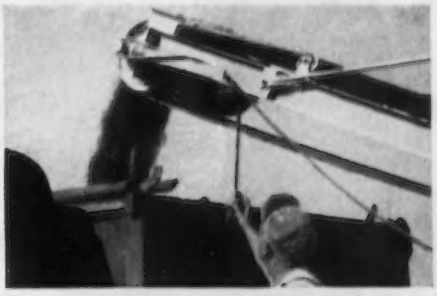
Cedarapids Inclined Double Deck Vibrating Screens are sturdily built to handle 2 to 3-ft. material. Eccentric shaft vibrating mechanism provides positive circle throw to assure big-volume output. Easily replaceable plate feed box and discharge lip reduce maintenance costs.



DOUBLE IMPELLER IMPACT BREAKERS

FOR PRIMARY AND SECONDARY CRUSHING IN ONE OPERATION

Double Impeller Impact Breakers are being used for more and more mining applications because of their exceptionally high output, design which permits a high percentage of material to be broken in suspension to minimize wear and reduce power requirements and the high reduction ratios which eliminate the need for secondary crushers in many instances. It will pay you to investigate all the many other advantages of Double Impeller Impact Breakers.



MOTORIZED HEAD PULLEYS

CUT CONVEYOR MAINTENANCE COSTS 70 TO 90%

Everything is contained inside the pulley shell! The complete elimination of chains, sprokets, V-belts, jack shafts, etc. eliminates 70 to 90% of conveyor maintenance costs. More and more mining companies are modernizing their conveyor systems with these revolutionary *Motorized* Pulleys to cut costs.

See your nearest Cedarapids Distributor for complete details

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for: DRILLING
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are engineered and built to operate efficiently under severe conditions. In addition to their rugged construction, safety of the operator has been a carefully considered factor. Designs are available for precision or rotary drilling, and to cover 50 ft. maximum elevation or 32 ft. width of drill round from one position of the jumbo. The ROGERS self-leveling hydraulic jib arms and platforms provide greatly increased efficiency in all face or roof operations . . . with resultant lowered mining costs.

ROGERS vertical fixed mast jumbo with dual operators' platforms; raises to 30 ft. elevation.

ROGERS WILL DESIGN and BUILD TO SUIT YOUR SPECIALIZED NEEDS

ROGERS hydraulic jib arm jumbo with one arm at lowest position. Each arm swivels horizontally to cover a face 20 ft. high by 16 feet wide.

ROGERS hydraulic jib arm jumbo, crawler mounted, air driven, controls on jumbo. Jib arms swivel to cover 15 x 15 ft. face

Pivoted boom jumbo with cross rail raised to maximum of 20 ft. Operators platforms and drill sashes remain level.

ROGERS combination vertical mast and hydraulic jib arm jumbo on electric driven crawler. Jib arms, platforms and cross rails may be raised and swiveled to cover 18 feet wide by 24 feet high.

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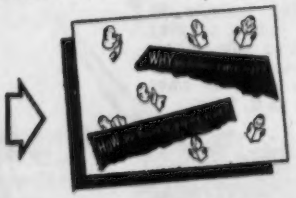

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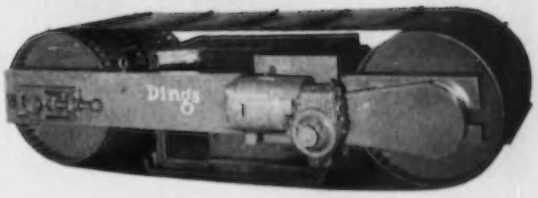

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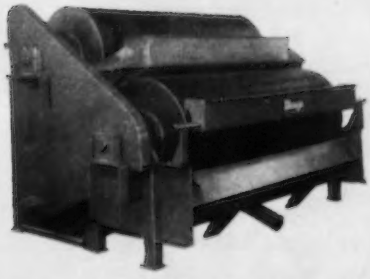

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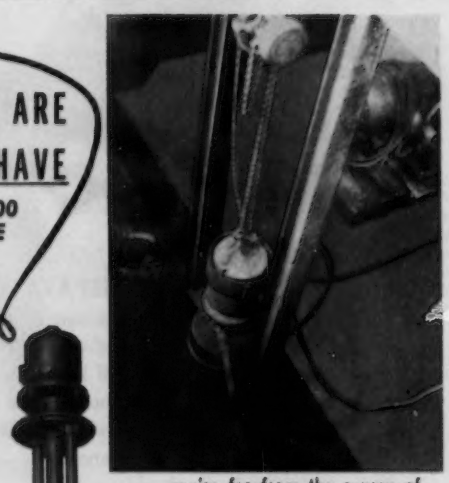

One of ten Nagle 2" type "QW-B," vertical shaft, centrifugal pumps is pictured recirculating spillage to a concentrator at the Paragsha Copper Concentrating Plant of Cerro de Pasco Corp., in Peru. Pump is suspended from chain hoist between guide rails for easy raising and lowering. Fifteen Nagle pumps used at this plant.

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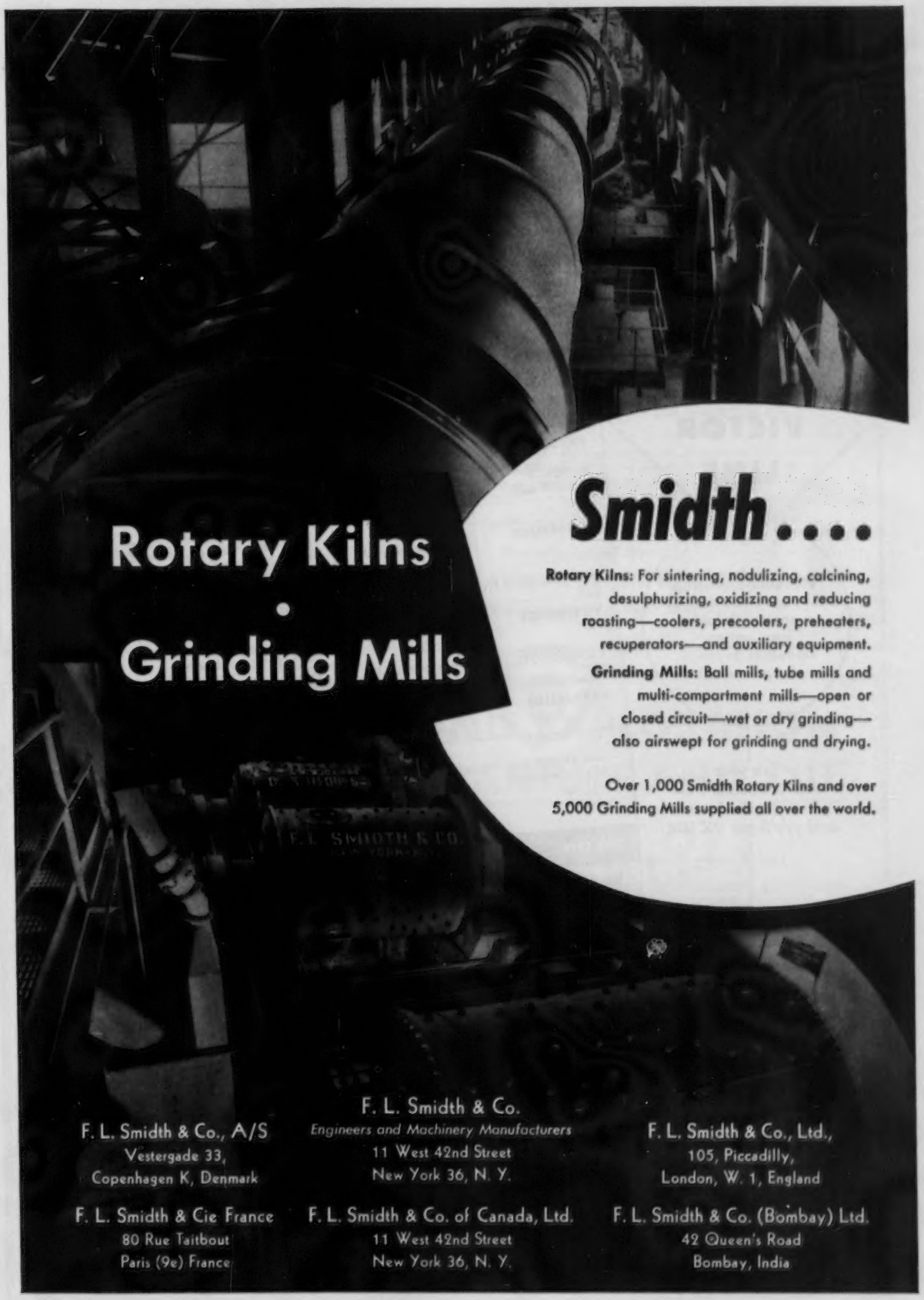

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VICTORITE	Earth abrasion or sliding friction	Plowshares, cultivators, steel mill guides, cement chutes, shaft bearings, rolling mill guides	Acety. AC-DC Elec.
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VA #3	Abrasion, light impact	Mill guides, crushers, dredge bushings
VA #4	Multiple layer build-up	Tractor rails, crane wheels, general build-up
VA #5	Heavy impact, abrasion	Tractor rollers, idlers, mine car wheels, sheave wheels
VA #6	Medium abrasion, high impact	Crane wheels, drums, roll necks
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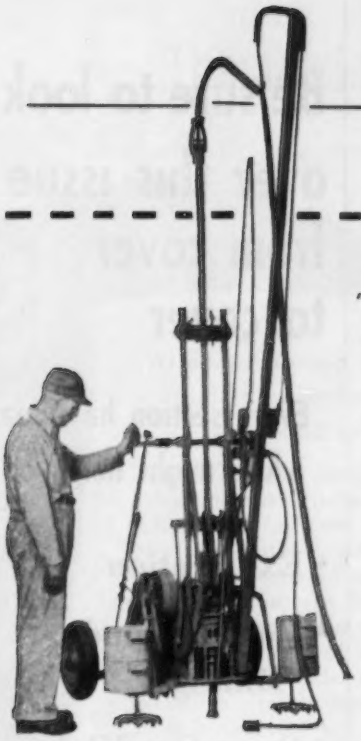

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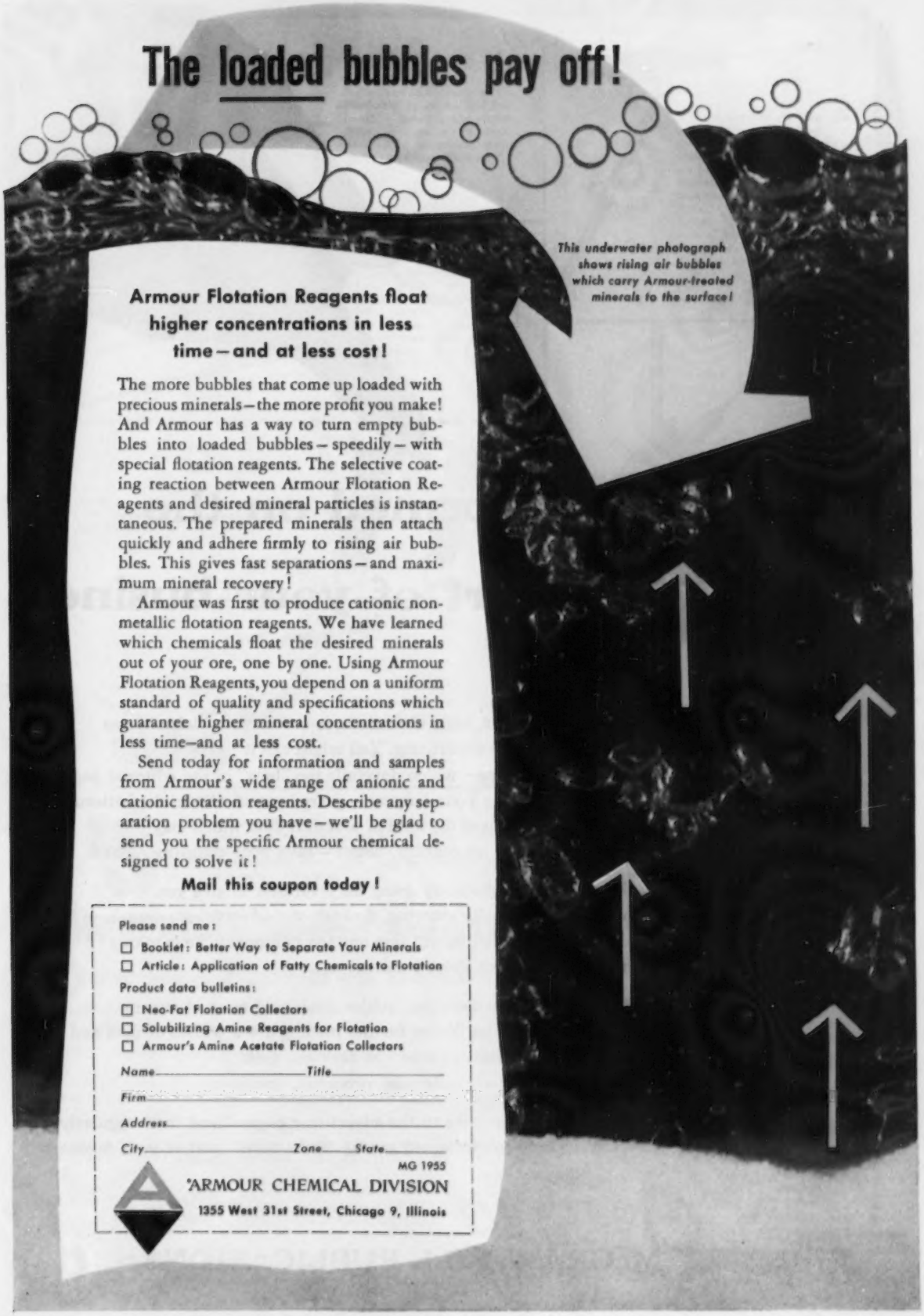

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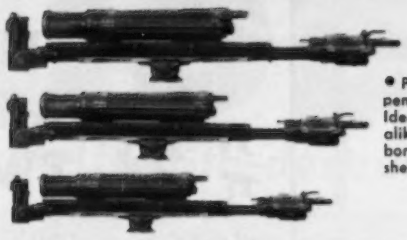

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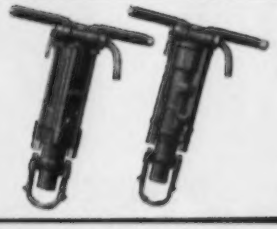

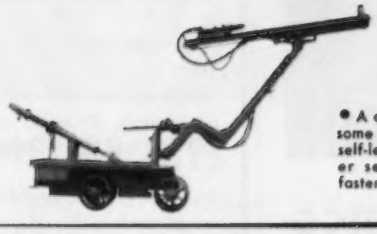

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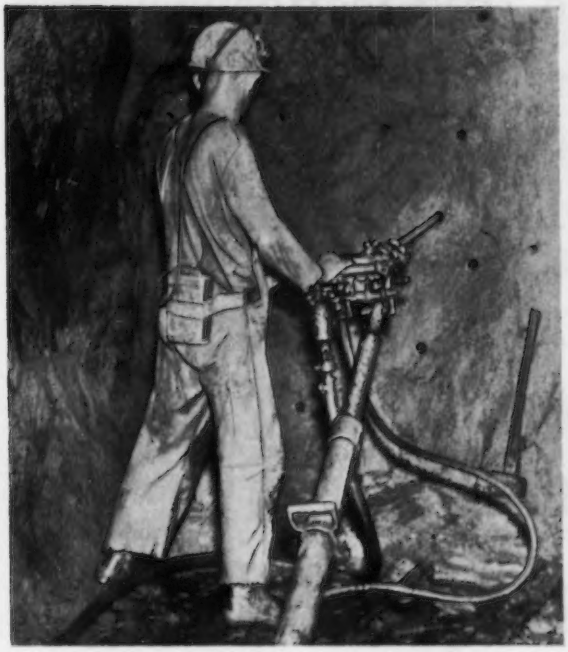
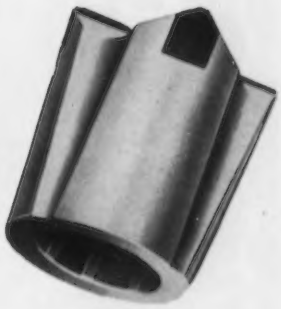


the bit for fast feed leg drilling



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- General Mine Plant Operations
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Special Service for Either Foreign or Domestic Production

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4. We also contract for mining production—shaft sinking—development.

ROGER V. PIERCE
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EXPLOSIVE BOXES

Approved by the Pa. Dep't. of Mines, these rigid non-conductive explosive boxes represent a prime safety investment. Made entirely of wood—tongue-grooved and dovetailed construction . . . no metal parts. . .automatic lock. . .rubber band spring . . . moisture-resistant. Box sizes are based on 1¼" x 8" sticks.

POWDER BOX PRICES ARE AS FOLLOWS:

No. 9	$2.55 ea.	No. 25	$5.10 ea.
No. 12	2.95 ea.	No. 36	6.50 ea.
No. 16	3.45 ea.	No. 50	7.60 ea.
No. 20	3.90 ea.	No. 72	8.70 ea.

DETONATOR BOX PRICES ARE AS FOLLOWS:

No. 6, size 2½" x 3" x 6" inside...$2.15 ea.
No. 8, size 2" x 2½" x 8" inside... 2.15 ea.

WOOD TAMPING POLES

For Tamping Explosive Shots: Poles are round, made of Hardwood. Sizes to 10' long. Price per lineal ft.: 1" dia. 8c; 1⅛" dia. 12c; 1¼" dia. 14c; 1⅜" dia. 16c; 1½" dia. 18c; 1¾" dia. 28c; 2" dia. 32c. Special diameters and lengths can be furnished. These Poles meet the requirements of the New Federal Mine Safety Code.

SECTIONAL TAMPING POLES

These poles are made of straight grained wood and are coupled together with removable wood pins held in place in recessed grooves by a rubber band and can be quickly connected and unconnected.
Couplers and Head Blocks are 4, 5 and 6 inches in diameter. Please specify size when ordering. Poles are 1½" in diameter.
Head Blocks, $3.70 ea.; Couplers, $3.90 ea.; Poles 12 feet long, $3.60 ea.; Poles 14 feet long, $4.20 ea.; Poles 16 feet long, $4.80 ea.; Poles 18 feet long, $5.30 ea.; Poles 20 feet long, $7.00 ea.; Poles 22 feet long, $8.80 ea.; Poles 24 feet long, $9.60 ea.

J. V. HAMMOND CO., Spangler, Pa.

We also manufacture Shot Firing Units, Wooden Mallet and Wedge Sets, Trolley Poles, Sounding Sticks, Mine Rollers, Insulation Blocks and Brake Blocks

Representatives of Shippers of ORES CONCENTRATES MINERALS METALS

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Inorganic Analyses to your requirements

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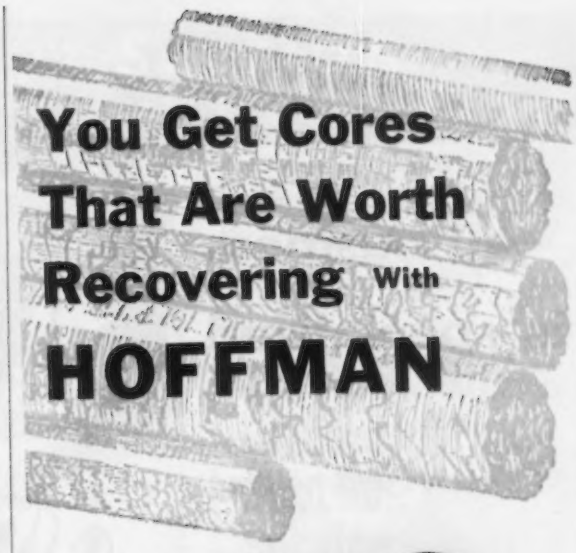

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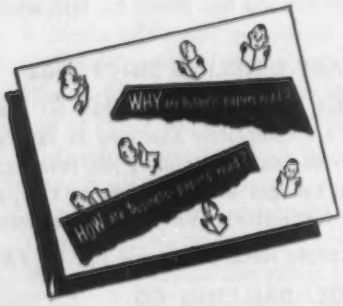

A copy of this quick-reading, 8-page booklet is yours for the asking. It contains many facts on the benefits derived from your business paper and tips on how to read more profitably. Write for the "WHY and HOW booklet." Room 2710.

McGRAW-HILL PUBLISHING COMPANY
330 West 42nd St., New York 36, N. Y.

One of a series of advertisements prepared by THE ASSOCIATED BUSINESS PUBLICATIONS

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CLASSIFIED SEARCHLIGHT SECTION ADVERTISING

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

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$1.50 a line. Minimum 3 lines. To figure advance payment count 5 average words as a line. (See ¶ on Box Numbers.)
POSITION WANTED undisplayed rate is one half of above rate, payable in advance.
PROPOSALS, $1.20 cents a line an insertion.

INFORMATION:

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DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).
EQUIPMENT WANTED OR FOR SALE Advertisements acceptable only in Displayed Style.

DISPLAYED RATE

The advertising rate is $13.80 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page.

Send NEW ADVERTISEMENTS to N. Y. Office, 330 W. 42 St., N. Y. 36, N. Y. For April Issue closing March 23rd.

FOR SALE
BUCKET LINE DREDGE

Located in California. In operating condition. 6 cubic foot buckets, 32 feet digging depth. Will handle 5 thousand yards per day. Built by the Walter W. Johnson Co. For further details write to:

KLAMATH DREDGING CO.

212 Stockton Street **San Francisco 8, California**

DOuglas 2-1688 **Cable Code: ANSOR**

GENUINE U.S. SIGNAL CORPS TELEPHONES AND COMMUNICATION WIRE!

BRAND NEW
U. S. N. KELLOGG TELEPHONES

EASY TO INSTALL TELEPHONE SYSTEMS. JUST RELEASED—U.S.N. TELEPHONES!

Home - ranch - industrial. String wire, connect to phones, ring and talk up to 20 miles. Perfect performance—battle-field proven.
Kellogg Mag.—5 Bar Wall Phone with handset. Each .....$19.90 **$37.50** per pair .....
EES Field Phones—Factory rec. like new. Each..$21.00. **$39.50** Per Pair .....

INSULATORS! Brand new, porcelain, 2 groove, screw type. 2 5/16" high x 1¾". Dia. 3" SPECIAL—boxes of 75.. **$3.95**

ALL WEATHER—ALL PURPOSE WIRE NEW SURPLUS—JUST RELEASED

On original factory steel reels. For communications, blasting, inter-com. Hundreds of other uses.
WI10B 18 ga. 2-conductor insulated copper-steel conductors. Unused, like new. 1 mile reels (5,280 ft.) **$17.50**
½ mile reels (2,640 ft.) **$10.00**

Other wire and phones not lis'ed. WRITE FOR FREE FOLDER.

BRAND NEW Latest Signal Corps. Field Wire WD12-2 conductor insulated heavy plastic-vinyl ½ mile reels **$20.95**

LORIS SALES P.O. Box 1896-EJ-5, Sacramento, Calif.

Send ck., m.o. or p.o. no c.o.d.'s—all prices f.o.b. - Sacramento - California Buyers add 3% Tax.

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Place an "Engineers Wanted" advertisement in the SEARCHLIGHT SECTION of Engineering and Mining Journal's regular monthly issues. It's an inexpensive, time saving method of selecting competent personnel for every engineering job in the mining industry. The selective circulation of Engineering and Mining Journal offers you the best opportunity to contact the best qualified men available throughout the industry.

SEARCHLIGHT Equipment Spotting Service

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used mining machinery not currently advertised. (This service is for USER-BUYERS only) No charge or obligation.

How to use: Check the dealer ads to see if what you want is not currently advertised. If not, send us the specifications of the equipment and/or machinery wanted using the coupon below, or your own company letterhead addressed to:

Searchlight Equipment Spotting Service Engineering and Mining Journal 330 W. 42nd St. N. Y. 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in our Searchlight Section. You will receive replies directly from them.

Searchlight Equipment Spotting Service Engineering and Mining Journal 330 W. 42nd St., N. Y. 36, N. Y.

Please help us locate the following equipment—machinery:

.....

.....

.....

.....

Name .....
Street .....
City ..... State .....

3/55

USED—REBUILT MACHINERY

BLOWERS
3—TM-8 Coppus Ventair, 15 HP
3—TM-6 Coppus Ventair, 5 HP
1—SM-425 Coppus Vano, 15 HP
1—SM-250 Coppus Vano, 1 HP
1—TM-5 Coppus Ventair, 2 HP
10—#2 Buffalo Mine Type, 3 HP
2—Joy Axivane 1-155 230 V DC

CAGES, VERTICAL
3—36" x 5', 40" between guides
1—30" x 46" floor—35" guides

CARDOX CHARGING PLANTS
1—Koreshell complete plant
1—Cardox complete plant with barrels

CARS
30—18 cu. ft., 18 gauge, RB, Card trucks, new bodies

CLASSIFIERS
1—8' x 26" Duplex Denver Rake
4—6' x 25' Dorr Duplex Rake
1—4½' x 16' Dorr Duplex Rake
1—24" x 11' Akins Spiral

COMPRESSORS
1—I-R 990 CFM, 200 HP motor
2—I-R 284 CFM, 75 HP motors
2—445 CFM, D-13000 Cat Engines, skidded

BELT CONVEYORS
1—48" x 81' centers, steel frame, 10 HP
1—36" x 120' Jeffrey—steel bridge frame and catwalk
1—18" x 56' Pioneer, bridge frame

CRUSHERS
2—2' Symons Std. Cones, 30 HP motors
1—9 x 16 Rogers, late model, jaw
1—9 x 36 Cedar Rapids, jaw

LABORATORY EQUIPMENT
2—9½K McCool Pulverizers
1—9½K DFC Pulverizer
2—Braun Type UA Pulverizers
1—Wilfley Table #13-S, 24" x 50"
9—Analytical and button balances
1—4½" x 10" Davis Jaw Crusher

FLOTATION EQUIPMENT
2—6-cell #15 Denver Sub A
1—5-cell #9-S Fagergren, 36"

DIESEL GENERATOR SETS
1—300 KW, 480 V. G.M. Engine, air starting
1—250 KW, 480 V. G.M. Engine, air starting
2—112½ KVA, 480 V. Cat. D-17,000 engines
2—100 KW, 480 V. Cummins L.I. Engines

HOISTS, MINE SHAFT
1—250 HP 2-drum shaft hoist, Denver
1—200 HP, 1-drum Nordberg, complete
1—150 HP, 1-drum Ottumwa
3—125 HP, 1-drum, herringbone gears

HOISTS, TUGGER AND SLUSHER
3—I-R HNN1J 2-drum air
5—I-R 25 MNN3D, 3-drum electric
2—I-R 20 MN2D, 2-drum electric

BALL AND ROD MILLS
3—5 x 10 Allis Chalmers, Rod
1—5 x 10 Stearns Roger, Rod
2—6' x 22" Hardinge Conical, 50 HP
1—7' x 36" Hardinge, 100 HP
1—7' x 48" Hardinge, 150 HP motor
2—4 x 5 Eimco & C.I.W., 40 HP
1—5 x 6 Allis Chalmers

LOCOMOTIVES
7—Mancha Titan A & B, 18" or 24" gauge, 3½ ton capacity
1—G.E. 2½ ton, Battery, 18-24 gauge
1—Plymouth 10-ton diesel, late model, std RR gauge

MUCKING MACHINES
5—Eimco 12-B, 18-24 ga. Rebuilt
1—GD-9 Gardner Denver, 18" ga. Rebuilt

TRANSFORMERS
2—250 KVA Allis Chalmers, 2400-480 V.
1—750 KVA Pittsburg, 44,000-2300 V.
1—1000 KVA G.E., 44,000-2300 V.

SPECIAL!!!
ROCK DRILLS AND PARTS
51—DA-35 Drifters & Power Feeds
19—FM-2 I-R Wagon Drills
$20,000 worth new DA35 & X-71 spare parts at discount.

MILLING MACHINERY IS OUR SPECIALTY

MACHINERY CENTER, INC.

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INDUSTRIAL RUBBER PRODUCTS

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62-66 Park Place, New York 7, N.Y. Digby 9-3810

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BUY "GUARANTEED RELAYERS"

Handle more cars better — spend less to install & maintain with Foster Relayers. "Open-stock" shipments, all sections 12# thru 175#. Switch Materials, Track items.

Send catalogs ☐ *Rails* ☐ *Track Equipment*
☐ *Send Free 'Track Maintenance' Book*

RAILS - TRACK EQUIPMENT - PIPE - PILING
L.B. FOSTER CO.
PITTSBURGH 30 NEW YORK 7
CHICAGO 4 HOUSTON 2 LOS ANGELES 5

ROTARY KILN FOR SALE

6' x 7' x 80' Long Rotary Kiln, shell ½" plate riveted construction two tires and trunnions and heavy driving gear. $8500.00 San Francisco Area.

H. T. NEAL MACHINERY CO.
#57 Post Street San Francisco, Calif.

FOR SALE

Unused surplus Neoprene Covered Telephone cable, Spiral-4, No. 19 AWG Stranded, 4 Conductor Rubber Insulated, with Terminal Couplings at each end, on Steel Reels, 1300 feet per reel. Weight per reel, 185 lbs.

Price, F.O.B. St. Louis, Mo. — $55.00 per reel. Liberal quantity discounts.

BUCKEYE TRADING CORPORATION
1315 Papin Street, St. Louis, Mo., CHestnut 1-3110

Your inquiry will have Special value . . .

If you mention this magazine, when writing advertisers. Naturally the publisher will appreciate it . . . but, more important, it will identify you as one of the men the advertiser wants to reach with this message . . . and help to make possible enlarged future service to you as a reader.

SINCE 1898 DEPENDABLE RECONDITIONED MACHINERY

BATTERY LOCOMOTIVES

1—2-2½ ton Whitcomb, 24″ gauge
1—2½ ton Jeffrey, 36″ gauge
2—3½ ton Mancha, 18″-32″ gauge; with 2 sets Edison batteries
1—3½ ton Atlas, 24″ gauge
1—4 ton Westinghouse, 24″ gauge
1—4 ton Ironton, 36″ gauge
2—5 ton General Electric, 24″ gauge
2—6 ton General Electric
1—6 ton Mancha Trackmaster, 24″ gauge, with 2 sets Gould KMZ-21 batteries
2—7 ton General Electric, 36″ gauge, permissible
1—7 ton Atlas, 36″-48″ gauge
2—8 ton General Electric, 36″ gauge
2—8 ton Goodman, 36″ gauge
3—8 ton Ironton, 24″-48″ gauge
4—10 ton Atlas, 36″ gauge

TROLLEY LOCOMOTIVES

1—4½ ton Goodman, 36″ gauge
1—5 ton Jeffrey, 36″ gauge
2—5 ton Jeffrey, 42″ gauge
1—6 ton Goodman, 36″ gauge
1—6 ton Goodman, 42″ gauge
2—8 ton Goodman, 42″ gauge
3—10 ton Jeffrey, 42″ gauge
1—13 ton Goodman, 42″ gauge
1—13 ton Jeffrey, 42″ gauge
3—15 ton Jeffrey, 42″ gauge

DIAPHRAGM PUMPS

3—2″ New Morse Diaphragm Pumps
1—4″ Barnes Pump
2—4″ Butchart Pumps
1—4″ Dorrco Pressure Diaphragm Pump

HOISTS

1—10 HP Vulcan #0 Single Drum
1—115 HP Morse New Single Drum
1—20 HP H&B Single Drum
1—22 HP Vulcan Single Drum #1½
1—30 HP Vulcan Double Drum
1—30 HP Vulcan Single Drum
1—37 HP Single Drum
2—52 HP Vulcan #4½ Single Drum
1—50 HP Fairbanks-Morse Single Drum
1—60 HP Vulcan #23ELF Single Drum
4—100 HP Box Single Drum
1—112 HP Vulcan Single Drum
2—150 HP Vulcan Single Drum
1—375 HP Dillon-Box Single Drum
1—22 HP Vulcan #1½ Double Drum
1—150 HP Dowco Double Drum Hoist
1—40 HP American 3 Drum
1—80 HP Thomas 3 Drum
1—80 HP Lidgerwood
1—80 HP Clyde 3 Drum

MUCKING MACHINES

1—Gardner-Denver Model 9
2—Eimco model 21 loaders
4—Conway model 50A loaders
1—Conway model 60 loader

CRUSHERS

3—2¼″ x 3½″ New Morse Lab Jaw Crushers
4—4″ x 6″ New Morse Lab Jaw Crushers
1—9″ x 15″ Wheeling Jaw Crusher
1—9″ x 15″ Farrell Jaw Crusher
1—8″ x 24″ Rogers Jaw Crusher
1—11″ x 18″ Universal Jaw Crusher
1—24″ x 13″ Farrell Jaw Crusher
1—10″ x 16″ Hercules Jaw Crusher
1—10″ x 16″ Universal #3M Jaw Crusher
1—26″ x 18″ Williams Hammermill

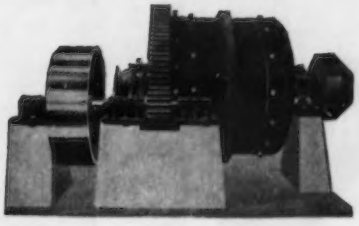
COMPRESSORS

1—44 CFM Ingersoll-Rand
2—88 CFM Ingersoll-Rand
1—179 CFM Ingersoll-Rand
1—360 CFM Gardner-Denver, model WBH, with 75 HP motor
1—447 CFM Ingersoll-Rand
1—637 CFM Sullivan
1—698 CFM Union
1—800 CFM Ingersoll-Rand
1—840 CFM Laidlow
1—1418 CFM Ingersoll-Rand

SLUSHER HOISTS

1—7½ HP Sullivan 2 Drum Slusher
1—10 HP Sullivan 3 Drum Slusher
1—Sullivan 2 Drum Model HD-10-B, driven by 30 HP Continental gas engine

BALL AND ROD MILLS



1—4′ x 3′ Marcy Ball Mill
1—4′ x 3′ Morse Ball Mill
1—6′ x 48″ Hardinge Conical Ball Mill
1—8′ x 22″ Hardinge Conical Pebble Mill
1—3′ x 8′ Marcy Rod Mill

TUGGER HOISTS

1—D6U Ingersoll-Rand Utility Air Hoist
1—Sullivan Model G-112, driven by 15 HP Wisconsin gas engine

PORTABLE COMPRESSORS

1—105 CFM Ingersoll-Rand, gas engine driven
1—105 CFM Worthington, gas engine driven
1—210 CFM Worthington, continental gas engine
1—230 CFM Gardner-Denver stationary, Buda gas engine
1—310 CFM Sullivan, Buda gas engine
1—310 CFM Gardner-Denver stationary, Buda gas engine

VIBRATING SCREENS

1—3′ x 8′ Simplicity 3 Deck
1—3′ x 12′ Symons Single Deck
1—4′ x 12′ Symons Double Deck
1—4′ x 12′ Tyler 3 Deck

CONCENTRATING TABLES

1—New #12 Wilfley Half Size
5—Deister Plat-O Tables

DIESEL GENERATORS

2—15 kw. Century Generators, 3/60/110-220, driven by Westinghouse Diesels
1—30 kw. Century Generator, 3/60/110-220, driven by Buda Diesel

SINKING PUMPS

1—2″ Ingersoll-Rand, 7½ hp. motor
1—2½″ Kroger, 20 hp. motor
1—3″ Chicago, 10 hp. motor
1—3″ Krogh, 25 hp. motor
1—14″ Layne & Bowler, 10 stage, 50 hp. motor

ROTARY BLOWERS

1—Connersville, size #36
1—Roots, 2½″ x 4″
3—Sutorbilt New, Model 3L
1—Sutorbilt, Model 7L
1—Victor-Acme, Size 717
1—Sutorbilt, Size 12-30
1—Connersville 14″ x 42″
1—Roots 16″ x 48″

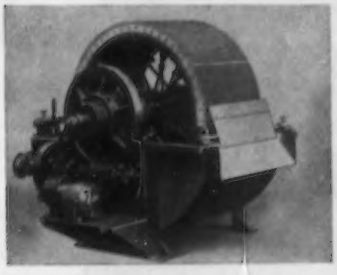
DRILLS

1—Ingersoll-Rand Drifter Model DA30, with Auto. Feed
3—Gardner-Denver Model 107 Drifters
5—Gardner-Denver Model D79 Drifters
7—Gardner-Denver Model S-55 Jackhammers
1—Ingersoll-Rand Model S-49 Stoper
1—Ingersoll-Rand Model FM-2 Wagon Drill

FLOTATION MACHINES

1—2 Cell New Morse "Jetair" #7
1—Fogregen Single Cell
1—Morse "Jetair" New Single Cell #7
1—6 Cell Denver "Sub-A" #21
1—Morse-Weinig 2 Cell, 37″ x 37″, Wood Tank

FILTERS



1—3′ x 3′ Oliver drum filter
2—4′ x 8′ Eimco drum filter
1—6′ x 2 disc Oliver leaf filter
1—6′ x 3 disc American leaf filter
1—18″ Morse round pattern filter press
1—36″ Merrill triangular filter press
1—#12 Sweetland filter press

MORSE BROS. MACHINERY COMPANY

2900 Brighton Blvd. P.O. Box 1708 Keystone 5261 DENVER, COLORADO

A REAGENT FEEDER
THAT DEFIES CORROSION

★ THE NEW CLARKSON
MODEL E IN RIGID PVC

★ Accurate
★ Economical
★ Corrosion-Proof
★ Wide Feeding Range
★ Complete Dependability

PROVED PERFORMANCE PLUS PVC

The Model E in stainless steel has long been the standard for precision feeding of reagents at low cost. The companion Model E in PVC for highly corrosive chemicals gives a complete service. Single units have a range from drops per minute to 750 gpd.

Write for Bulletins 540 and 541 for complete specifications.

THE CLARKSON COMPANY
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- Underground Mining
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- Milling and Concentrating
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- General Mine Plant Operations
- Advertisement
- Buying Directory

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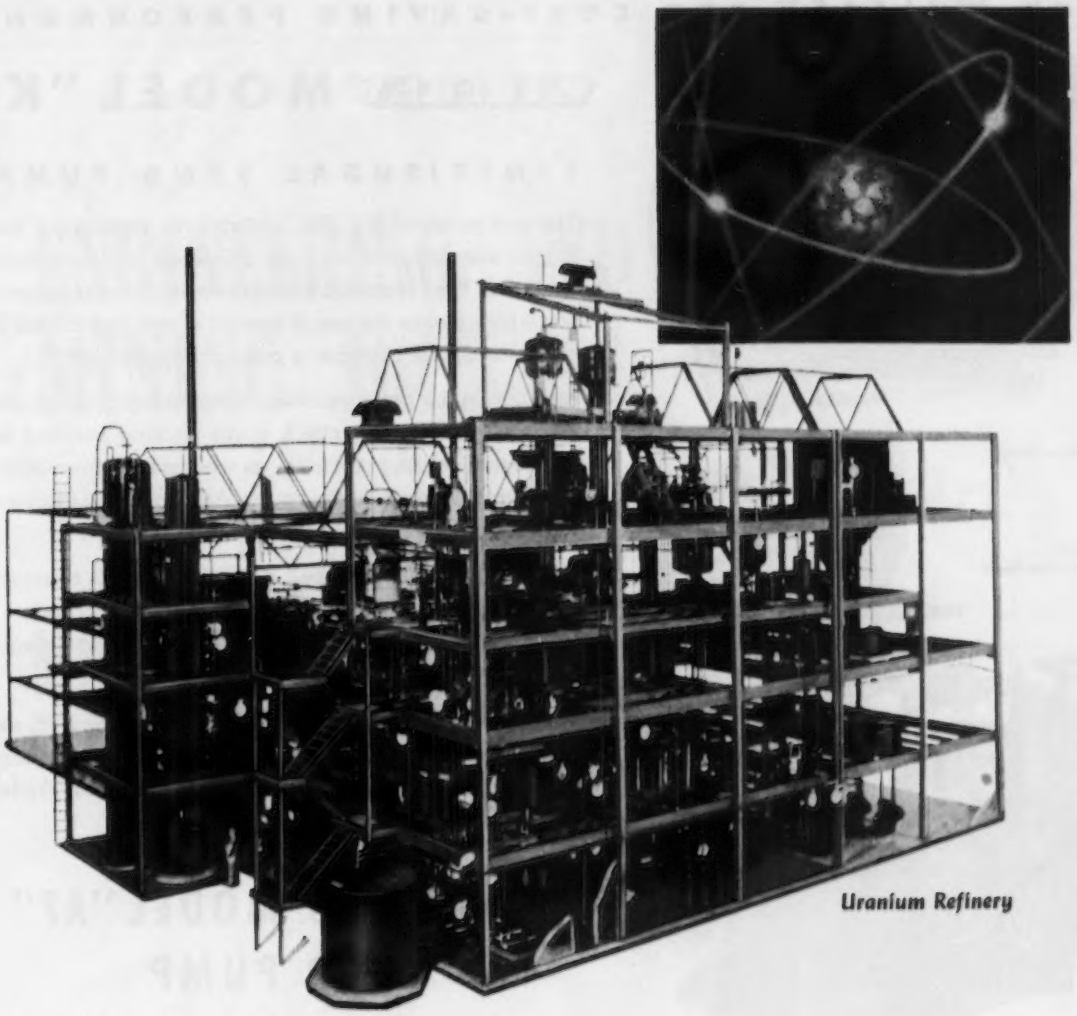
Buying Directory issue



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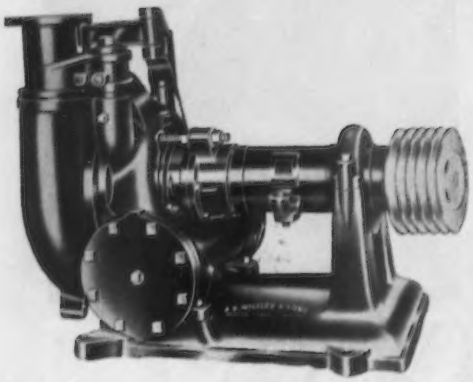
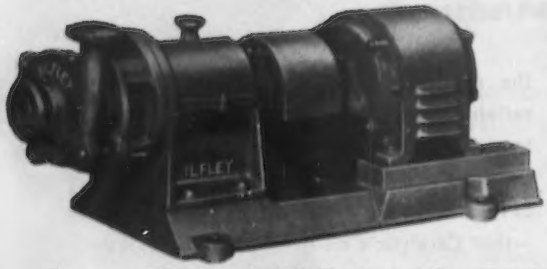


Belt Driven Pump

Overhead V-Belt Driven Pump



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The new patented WILFLEY Model "K" Centrifugal Sand Pumps are designed for high efficiency and trouble-free operation. They feature a special two-piece frame construction which makes the use of special alloys and rubber lining in the intake chamber a practical application.

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Western Canada, Manitoba Bridge & Iron Works, Ltd., Winnipeg, Man., Canada

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ENGINEERING AND MINING JOURNAL

1955

MINING GUIDEBOOK

BUYER'S GUIDE

WHO SUPPLIES IT? . . . Section 1 of this Buyer's Guide gives you an alphabetical list of products and services used in the metal and non-metallic mining industry together with the names of those who furnish them. We have tried to include only primary manufacturers especially interested in the mining industry. They will willingly act on all your inquiries including reference to local distributors and suppliers. Those in bold type have a special message for you in this Guidebook; the page number of their ad is given with their address in the second section.

WHERE ARE THEY? . . . Section 2 of this Buyer's Guide gives you the addresses of all companies listed in the first section. They are arranged alphabetically by parent company name so far as it was possible to determine. Advertisers are shown in bold type, followed by the page number of their ad. You will find the ad contains more information on a product or service designed to help you cut costs and increase production.

SECTION 1 : PRODUCTS & SERVICES →

E&MJ's Buyer's Guide to Manufacturers' Products and Services

ABRASIVES
American Wheelabrator & Equip. Corp.
Armour & Co., Chemical Div.
Carborundum Co.
Continental Mineral Proc. Corp.
Ideal Industries, Inc.
Minnesota Mining & Mfg. Co.
Norton Co.
Patrick Co., R. S.
Simonds Saw & Steel Co., Simonds Abrasive Co., Div.
Smit & Sons, J. K. Inc.

ACETYLENE GENERATORS
Air Reduction Co., Inc.
Linde Air Products Co.
Sight Feed Generator Co.
Victor Equipment Co.

AERATORS
Bin-Dicator Co.
Jeffrey Mfg. Co.

AERIAL TRAMWAYS & CABLEWAYS
American Hoist & Derrick Co., Crosby Products Div.
Arrowhead Steel Buildings Inc.
Beaumont Birch Co.
Colorado Fuel & Iron Corp.
Roebling's Sons Co., John A.
Flory Mfg. Co.
Jones & Laughlin Steel Corp.
Link-Belt Co.
Neal Machinery Co., H. T.
Riblet Tramway Co.
Sauerman Bros., Inc.
Stearns-Roger Mfg. Co.
Superior-Lidgerwood-Mundy Corp.
U. S. Steel Corp., Columbia-Geneva Steel Div.
U. S. Steel Corp., American Steel & Wire Div.
U. S. Steel Export Co.
Washington Iron Works
Yara Engineering Corp.
Interstate Equipment Div.

AFTERCOOLERS
Carrier Conveyor Corp.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Kewanee-Ross Corp.
Pennsylvania Pump & Compressor Co.
Schramm, Inc.
Southwestern Engineering Co.
Wooldridge Mfg. Co.
Worthington Corp.

AGITATORS
Bin-Dicator Co.
Bodinson Mfg. Co., Inc.
Christian Engineers, J. D.
Dagley Mfg. Co.
Denver Equipment Co.
Dorr-Oliver Inc.
Eimco Corp.
Galigher Co.
General American Transportation Corp.
Hardinge Co., Inc.
Smidth & Co., F. L.
Stearns-Roger Mfg. Co.
Straub Mfg. Co.
Western Machinery Co.
Worthington Corp.

AIRCRAFT
Beech Aircraft Corp.
Bell Aircraft Corp.
Cessna Aircraft Corp.

AIR COMPRESSORS—see Compressors

AIR LINE OILERS
Acme Machinery Co.
Chicago Pneumatic Tool Co.
Copco Pacific, Ltd.
Gardner-Denver Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Reed Roller Bit Co.
Thor Power Tool Co.
Victor Equipment Co.

AIR MOTORS
Acme Machinery Co.
Chicago Pneumatic Tool Co.
Eimco Corp.
Gardner-Denver Co.
Graybar Electric Co., Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
McCulloch Motors Corp.
Reed Roller Bit Co.
Thor Power Tool Co.

AIR PREHEATERS
Combustion Engineering, Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kewanee Ross Corp.
Majac, Inc.
Southwestern Engineering Co.

AIR RECEIVERS
Acme Machinery Co.
Copco Pacific, Ltd.
Ingersoll-Rand Co.
Joy Mfg. Co.
Southwestern Engineering Co.
Wooldridge Mfg. Co.

AMALGAMATORS
Denver Equipment Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Straub Mfg. Co.
Titan Chain Saws, Inc.

AMMETERS & VOLTMETERS
Beckman Instruments, Inc., Berkeley Div.
Braun Corp.
Bristol Co.
General Electric Co., Apparatus Sales Div.
Graybar Elec. Co. Inc.
Westinghouse Electric Corp.
Weston Electrical Instrument Corp.

ANEMOMETERS
Batson Electronics Corp., J. A.
Braun Corp.
Burrell Corp.
Davis Instrument Mfg. Co.
Mine Safety Appliances Co.
New Jersey Meter Co.

ARCH PLATES—See Mine Supports

ARRESTERS, LIGHTNING
General Electric Co., Apparatus Sales Div.
Ohio Brass Co.
Westinghouse Electric Corp.

BAGS, FILTER
Ducon Co.
Eimco Corp.
Filter Fabrics Inc.
Mechanical Industries, Inc.
National Filter Media Corp.
Portland Woolen Mills Inc.
Stanley Co., Inc., William W.
U. S. Hoffman Corp., Air Appl. Div.

BAGS, PAPER OR FABRIC
Bemis Bros. Bag Co.
Central Mine Supply Co.
Chase Bag Co.
Equitable Paper Bag Co.
Filter Fabrics Inc.
Fulton Bag & Cotton Mills, Inc.
International Paper Co.
St. Regis Paper Co.
Union Bag & Paper Corp.

BAGS, POWDER
Bemis Bros. Bag Co.
Equitable Paper Bag Co.
Mine Safety Appliances Co.

BAGS, TAMPING
Atlas Powder Co.
Bemis Bros. Bag Co.
Central Mine Supply Co.
Equitable Paper Bag Co.
National Powder Co.
Union Bag & Paper Co.

BAG FILLING MACHINES
Food Machinery & Chemical Corp.
St. Regis Paper Co.

BALL MILLS—see Mills, Ball, etc.

BALLS, GRINDING
American Brake Shoe Co.
American Forge Co.
Armco Steel Corp., Sheffield Steel Div.
Braun Corp.
Calumet & Hecla, Inc.
Coates Steel Products Co.
Coeur d'Alene Hardware & Foundry Co.
Colorado Fuel & Iron Corp.
Coors Porcelain Co.
Denver Equipment Co.
Eagle Iron Works
General Electric Co., Apparatus Sales Div.
Hardinge Co., Inc.
Hayes Steel Products, Ltd.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Mine and Smelter Supply Co., Marcy Mill Div.
National Malleable & Steel Castings Co.
Straub Mfg. Co.
Treadwell Engrg. Co.
U. S. Steel Corp.
Vitro Corp. of America

BATTERIES, STORAGE
Armstrong Rubber Co.
Auto-Lite Battery Corp.
Bowers Battery & Spark Plug Co.
C & D Batteries, Inc.
Edison, Inc., Thomas A., Edison Storage Battery Div.
Electric Storage Battery Co.
Gould-National Batteries, Inc.
Graybar Electric Co.
Gulf Oil Corp.
KW Battery Co.
National Mine Service Co.
Ray-O-Vac Co.
Seiberling Rubber Co.
Union Carbide & Carbon Corp., National Carbon Co. Div.
United States Rubber Co., U. S. Royal Tire Div.
Yardney Electric Corp.

BATTERY CHARGERS
Electro Products Lab.
General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
Goodman Mfg. Co., Mancha Storage Battery Locomotive Div.
Gould-National Batteries, Inc.
Graybar Elec. Co. Inc.
Hobart Brothers
International General Electric Co.
Ironton Engine Co.
K-W Battery Co.
Kersey Mfg. Co.
Lincoln Electric Co.
Mine Safety Appliances Co.
Westinghouse Electric Corp.

BATTERY TRANSFER RACKS
General Electric Co., Apparatus Sales Div.
Goodman Mfg. Co.
Gould-National Batteries, Inc.

BEARING METAL
American Brake Shoe Co.
American Crucible Products Co.
American Smelting and Refining Co.
Ampco Metal, Inc.
Bunting Brass & Bronze Co.
Federal-Mogul Corp.
Flood City Brass & Elec. Corp.
Heyl & Patterson, Inc.
Magnolia Metal Co.
Marlin Rockwell Co.
National Lead Co.
Ryerson & Son., Inc., J. T.
Torrington Co., Bantam Bearings Div.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.

BEARINGS, BALL
Ahlberg Bearing Co.
Dodge Mfg. Corp.
Dominion Engineering Co., Ltd.
Fafnir Bearing Co.
Federal Bearings Co., Inc.
Federal-Mogul Corp., Federal-Mogul Service Div.
General Motors Corp., New Departure Div.
Link-Belt Co.
Marlin Rockwell Co.
Nice Ball Bearing Co.
Norma-Hoffmann Bearings Corp.
Schatz Mfg. Co.
SKF Industries, Inc.
Stephens-Adamson Mfg. Co.
Torrington Co.

BEARINGS, NEEDLE
General Motors Sales Corp., Hyatt Bearings Div.
Marlin Rockwell Co.
Orange Roller Bearing Co. Inc.
Torrington Co., Bantam Bearings Div.

BEARINGS, ROLLER
Bower Roller Bearing Co.
Chain Belt Co., Shafer Bearing Div.
Cooper Split Roller Bearing Corp.
Dodge Mfg. Corp.
Dominion Engineering Co., Ltd.
Federal-Mogul Corp.
General Motors Corp., Hyatt Bearings Div.
Link-Belt Co.
Marlin-Rockwell Corp.
Norma-Hoffmann Bearings Corp.
Orange Roller Bearing Co. Inc.
Rollway Bearing Co.
SKF Industries, Inc.
Timken Roller Bearing Co.
Torrington Co., Bantam Bearings Div.

BEARINGS, SLEEVE
American Brake Shoe Co.
American Crucible Products Co.
Chain Belt Co.
Dodge Mfg. Corp.
Federal-Mogul Corp., Federal-Mogul Service Div.
Flood City Brass & Electric Co.
Link-Belt Co.
Marlin-Rockwell Corp.
Olds Alloy Co.
Ryerson & Son, Inc., J. T.
Tool Steel Gear & Pinion Co.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.

BELTS, CONVEYOR—See Conveyor Belting

BELTS, FLAT TRANSMISSION
American Rubber Mfg. Co.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co.
Gates Rubber Co.
Goodall Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins, Inc.
Houghton & Co., E. F.
Lee Rubber & Tire Corp., Republic Rubber Div.
Manheim Mfg. & Belting Co.
Meckum Engrg. Co.
New York Belting & Packing Co.
New York Rubber Corp.
Porter Co., H. K., Quaker Rubber Div.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Scandinavia Belting Co.
Thermoid Co.
U. S. Rubber Co.
Webb Corp.

BELTS, "V"
Allis-Chalmers Mfg. Co.
American Pulley Co.
Boston Woven Hose & Rubber Co.
Browning Mfg. Co.
Carlyle Rubber Co.
Continental Gin Co.
Dayton Rubber Co.
Dodge Mfg. Corp.
Gates Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Iowa Mfg. Co.
Jones Foundry & Machine Co., W. A.
Lee Tire & Rubber Co. Republic Rubber Div.
Link-Belt Co.
Lovejoy Flexible Coupling Co.
Manheim Mfg. & Belting Co.
Meckum Engrg. Co.
New York Belting & Packing Co.
Porter Co., H. K. Quaker Rubber Div.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Thermoid Co.
U. S. Rubber Co.
Webb Corp.
Worthington Corp.

BELT DRESSING
Dixon Crucible Co.
Houghton & Co., E. F.
Scandinavia Belting Co.

BINS & CHUTES
Barber-Greene Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Butler Bin Co.
Connellsville Mfg. & Mine Supply Co.
Enterprise Wheel & Car Corp.
General American Transportation Corp.
Goodman Mfg. Co.
Hendrick Mfg. Co.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Koehring Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
Mayo Tunnel & Mine Equip. Co.
McNally Pittsburg Mfg. Co.
Meckum Engrg. Co.
Neff & Fry Co.
Pioneer Engineering Works, Inc.
Rogers Iron Works Co.
Sanford-Day Iron Works, Inc.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
St. Regis Paper Co.
Sturtevant Mill Co.

Thompson-Starrett Co., Inc.
Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Webb Corp.
Webster Mfg. Inc.
Wooldridge Mfg. Co.
Yuba Mfg. Co.

BIN AND CHUTE GATES

Bodinson Mfg. Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co.
Enterprise Wheel & Car Corp.
General American Transportation Co.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Koehring Co.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
Mine and Smelter Supply Co., Marcy Mill Div.
McNally Pittsburg Mfg. Co.
Neff & Fry Co.
Sanford-Day Iron Works, Inc.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
Thompson-Starrett Co., Inc.
Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Webb Corp.
Webster Mfg. Inc.
Yuba Mfg. Co.

BIN-LEVEL INDICATORS

Bin-Dicator Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co.
Convair Corp.
Hewitt-Robins, Inc.
Jeffrey Mfg. Co.
Koehring Co.
Neff & Fry Co.
Stephens-Adamson Mfg. Co.
Syntron Co.

BLAST CLEANING EQUIPMENT

American Wheelabrator & Equip. Corp.
Pangborn Corp.

BLASTING CAPS

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
duPont de Nemours & Co., E. I. Explosives Dept.
Hammond Co., J. V.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.
National Powder Co.
Western Cartridge Co.

BLASTING CAP & FUSE SEALS

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
Coast Mfg. & Supply Co.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.

BLASTING COMPOUNDS—
see Explosives

BLASTING & DETONATING FUSES

American Cyanamid Co.
Atlas Powder Co.
Coast Mfg. & Supply Co.
duPont de Nemours & Co., E. I. Explosives Dept.
Ensign-Bickford Co.
Hercules Powder Co.
Illinois Powder Co.
King Powder Co.
National Fuse & Powder Co.
National Powder Co.

BLASTING EQUIPMENT & ACCESSORIES

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
Coast Mfg. & Supply Co.
Davis Instrument Mfg. Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
Femco Inc.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.
Mine Safety Appliances Co.
Minnesota Mining & Mfg. Co.
Irvington Varnish & Insulator Div.
National Powder Co.
Victor Equipment Co.

BLASTING FUSE LIGHTERS, SAFETY

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
Coast Mfg. & Supply Co.
du Pont de Nemours & Co., Inc., E. I., Explosives Dept.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.
National Fuse & Powder Co.
National Powder Co.

BLASTING IGNITERS, ELECTRICAL DELAY

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
du Pont de Nemours & Co., Inc., E. I., Explosives Dept.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.
National Powder Co.

BLASTING SQUIBS

American Cyanamid Co., Explosives Dept.
Atlas Powder Co.
du Pont de Nemours & Co., Inc., E. I., Explosives Dept.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.

BLASTING TAMPING PLUGS

Illinois Powder Mfg. Co.
King Powder Co.
National Automotive Fibres, Inc.
National Mine Service Co.
Quick-Seal Products, Inc.

BLASTING WIRE

Chester Cable Corp.
Colorado Fuel and Iron Corp., John A. Roebling's Sons Co.

BLOCKS & SHEAVES—also see Pulleys and Sheaves

Alloy Steel & Metals Co.
American Hoist & Derrick Co.
Card Iron Works Co., C. S.
Graybar Elec. Co., Inc.
Hewitt-Robins, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Joy Mfg. Co.
Lake Shore Engineering Co.
Madesco Tackle Block Co.
Meckum Engr. Co.
Riblet Tramway Co.
Sanford-Day Iron Works, Inc.
Sauerman Bros., Inc.
Stookum Co.
Thompson-Starrett Co., Inc.
Roberts & Schaefer Co.
Upson-Walton Co.
Washington Iron Works

BLUE, PHOTO & WHITE, PRINT MACHINES

Bruning Co., Charles
General Aniline & Film Corp., Ozalid Div.
Peck & Harvey Co.
Union Carbide & Carbon Corp., Nat. Carbon Co. Div.

BOILERS

Babcock & Wilcox Co.
Combustion Engineering, Inc.
Condenser Service & Engrg. Co.
Foster Wheeler Corp.
Kennedy-Van Saun Mfg. & Eng. Corp.
Leffel & Co., James
Stearns-Roger Mfg. Co.
Vogt Machine Co., Henry

BOLTS—see Fasteners or Rock Bolts

BOOMS, LOADING—also see Cranes

Dominion Engineering Co., Ltd.
Hewitt-Robins, Inc., Robins Conveyors Div.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
McNally Pittsburg Mfg. Co.
Savage Co., W. J.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.

BOXES, JOURNAL

Bodinson Mfg. Co., Inc.
Card Iron Works Co., C. S.
Chain Belt Co.
Coeur d'Alene Hardware & Foundry Co.
Dodge Mfg. Co.
Enterprise Wheel & Car Corp.
Flood City Brass & Electric Co.
General Motors Sales Corp. Hyatt Bearings Div.
Ironton Engine Co.
Maddox Foundry & Machine Wks., Inc.
McNally Pittsburg Mfg. Co.
National Malleable & Steel Castings Co.
Phillips Corp.
Sanford-Day Iron Works Inc.
Webster Mfg. Inc.

BRAKES, FRICTION-BLOCKS, SHOES AND LININGS

American Brake Shoe Co.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Ironton Engine Co.
Johns-Manville Corp.
Maddox Foundry & Machine Wks., Inc.
Raybestos-Manhattan, Inc.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
Sanford-Day Iron Works, Inc.
Scandinavia Belting Co.
Thermoid Co.
Vulcan Iron Works (Pa.)

BRAKES, MAGNETIC

Cutler-Hammer, Inc.
Dings Magnetic Separator Co.
Eaton Manufacturing Co. Dynamatic Div.
General Electric Co., Apparatus Sales Div.
Magnetic Engineering & Mfg. Co.
Stearns Magnetic, Inc.
Westinghouse Electric Corp.

BRATTICE CLOTH

American Brattice Cloth Corp.
Daniels Co., Contractors, Inc.
Flocker & Co., John
Fulton Bag & Cotton Mills, Inc.
Rockwell Spring & Axle Co. Timken-Detroit Axle Div.
Turner Halsey Co.
Wellington Sears Co.

BREAKERS, CIRCUIT

Allis-Chalmers Mfg. Co.
Cutler-Hammer, Inc.
Electric Controller & Mfg. Co.
Federal Pacific Electric Co.
General Electric Co., Appar. Sales Div.
Graybar Electric Co.
I-T-E Circuit Breaker Co.
Square D Co.
Westinghouse Electric Corp.

BRUSHES, ELECTRICAL

General Electric Co. Apparatus Sales Div.
Ohio Carbon Co.
Pure Carbon Co.
Stackpole Carbon Co.
Union Carbide & Carbon Corp., National Carbon Co. Div.

BUCKETS, CLAMSHELL & GRAB

Blaw-Knox Co.
Harnischfeger Corp.
Heyl & Patterson, Inc.
Industrial Brownhoist Corp.
McKiernan-Terry Corp.
Orton Crane & Shovel Co.
Owen Bucket Co.
Pettibone Mulliken Corp.
"Quick-Way" Truck Shovel Co.
Wellman Engineering Co.
Yuba Mfg. Co.

BUCKETS, CONVEYOR & ELEVATOR

American Conveyor Co.
Atlas Conveyor Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Chain Belt Co.
Continental Gin Co., Industrial Div.
Hendrick Mfg. Co.
Hewitt-Robins, Inc., Robins Conveyor Div.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Manufacturing Co.
Jeffrey Mfg. Co.
Koehring Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
Meckum Engr. Co.
McNally Pittsburg Mfg. Co.
Remaly Mfg. Co.
Rogers Iron Wks. Co.
Stephens-Adamson Mfg. Co.
Taylor-Wharton Iron & Steel Co.
Universal Engineering Co.
Universal Road Machinery Corp.
Watt Car & Wheel Co.
Webb Corp.
Webster Mfg., Inc.
Wilmot Engineering Co.
Yuba Mfg. Co.

BUCKETS, DRAGLINE

Bucyrus-Erie Co.
Dominion Engineering Co., Ltd.
Electric Steel Foundry Co.
Harnischfeger Corp.
Hendrix Mfg. Co.
Insley Manufacturing Corp.
Koehring Co.
Link-Belt Speeder Corp.
Meckum Engrg. Co.
Page Engineering Co.
Pettibone Mulliken Corp.
"Quick-Way" Truck Shovel Co.
Sauerman Bros., Inc.
Schield Bantam Co.
Sorel Steel Foundries, Ltd.
Taylor-Wharton Steel & Iron Co.
Wellman Engineering Co.
Yaun Mfg. Co., Inc.

BUCKETS, DREDGE

American Brake Shoe Co. American Manganese Steel Div.
Hayward Co.
Kensington Steel Co.
Meckum Engrg. Co.
Sorel Steel Foundries, Ltd.
Taylor-Wharton Iron & Steel Co.
Yuba Mfg. Co.

BUCKETS, DUMPING & SINKING

Denver Equipment Co.
Easton Car & Construction Co.
Hayward Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.

BUCKETS, TRAMWAY

Hayward Co.
Riblet Tramway Co.
Yara Engrg. Corp., Interstate Equip. Div.

BUILDING, METAL PREFAB

Armco Drainage & Metal Products Inc.
Arrowhead Steel Buildings, Inc.
Butler Mfg. Co.
Columbian Steel Tank Co.
Soule Steel Co.

BULLDOZERS

Allis-Chalmers Mfg. Co., Tractor Div.
American Tractor Equipment Co.
Austin Western Co.
Baker Mfg. Co.
Caterpillar Tractor Co.
Colorado Fuel & Iron Corp.
Drott Mfg. Co.
Elmco Corp.
Electric Steel Foundry Co.
Gar Wood Industries, Inc.
Hyster Co.
International Harvester Co.
LeTourneau-Westinghouse Co.
Oliver Corp.
Wooldridge Mfg. Co.

BULLDOZER & GRADER BLADES

Baker Mfg. Co.
Colorado Fuel & Iron Corp.
Electric Steel Foundry Co.

CABLE, ELECTRICAL

Aluminum Co. of America
American Chain & Cable
Anaconda Wire & Cable Co.
Chester Cable Corp.
Collyer Insulated Wire Co.
Colorado Fuel and Iron Corp., Roebling's Sons Co., John A.
Crescent Insulated Wire & Cable Co.
Essex Wire Corp.
Flocker & Co., John
General Cable Corp.
General Electric Co., Construction Materials Div.
Graybar Electric Co.
Hatheway & Co.
Joy Manufacturing Co.
Kerite Co.
National Electric Products Corp.
Noma Electric Corp., Ansonia Electrical Div.
Okonite Co.
Phelps Dodge Copper Products Corp., Habirshaw Cable & Wire Div.
Rockbestos Products Corp.
Rome Cable Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co.
U. S. Rubber Co.
U. S. Steel Corp., American Steel & Wire Div.
Western Insulated Wire Co.

CABLE, ELECTRICAL, ARMORED

Anaconda Wire & Cable Co.
Chester Cable Corp.
Collyer Insulated Wire Co.
Colorado Fuel and Iron Corp., Roebling's Sons Co., John A.
Flocker & Co., John
General Cable Corp.
General Electric Co., Construction Materials Div.
Graybar Electric Co.

Kerite Co.
National Electric Products Corp.
Noma Electric Corp.
Ansonia Electrical Div.
Okonite Co.
Phelps Dodge Copper Products Corp., Habirshaw Cable & Wire Div.
Rockbestos Products Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co.
U. S. Steel Corp., American Steel & Wire Div.
U. S. Steel Corp., Columbia-Geneva Steel Div.

CABLE ELECTRICAL NON-METALLIC SHEATHED

Anaconda Wire & Cable Co.
Chester Cable Corp.
Collyer Insulated Wire Co.
Colorado Fuel and Iron Corp., Roebling's Sons Co., John A.
Flocker & Co., John
General Cable Corp.
General Electric Co., Construction Materials Div.
Graybar Electric Co.
National Electric Products Corp.
Okonite Co.
Phelps Dodge Copper Products Corp., Habirshaw Cable & Wire Div.
Rockbestos Products Corp.
Rome Cable Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co.
U. S. Rubber Co.
U. S. Steel Corp., Columbia-Geneva Steel Div.
Western Insulated Wire Co., Inc.

CABLE CONNECTORS

American Hoist & Derrick Co.
Anderson Mfg. Co., Albert & J. M.
Burndy Engineering Co.
Elreco Corp.
Ensign Electric & Mfg. Co.
Flood City Brass & Electric Co.
Graybar Electric Co., Inc.
Joy Mfg. Co.
National Electric Products Corp.
Ohio Brass Co.
Victor Equipment Co.

CABLE SPLICERS

American Mine Door Co.
Burndy Engineering Co.
Elreco Corp.
Ensign Electric & Mfg. Co.
Flocker & Co., John
Flood City Brass & Elec. Co.
Graybar Elec. Co. Inc.
Joy Mfg. Co.
Mine Safety Appliances Co.
Ohio Brass Co.
U. S. Rubber Co., Mechanical Goods Div.

CARBIDE

Air Reduction Sales Co., National Carbide Co., Div.
Union Carbide & Carbon Corp.

CARBIDE CAP LAMPS

Justrite Mfg. Co.
Mine Safety Appliances Co.

CARS, AIR DUMP

Atlas Car & Mfg. Co.
Baldwin-Lima-Hamilton Corp.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Differential Steel Car Co.
Gardner-Denver Co.
Gregg Co., Ltd.
Lake Shore Engineering Co.
Magor Car Corp.

CARS, AUTOMATIC DUMP

Atlas Car & Mfg. Co.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Differential Steel Car Co.
Easton Car & Construction Co.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Lake Shore Engineering Co.
Mayo Tunnel & Mine Equip. Co.
McNally Pittsburg Mfg. Co.
Phillips Corp.
Pressed Steel Car Co.
Sanford-Day Iron Works, Inc.
Stephens-Adamson Mfg. Co.

CARS, HAND DUMP

Atlas Car & Mfg. Co.
Bethlehem Steel Co.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Denver Equipment Co.
Differential Steel Car Co.
Easton Car & Construction Co.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Lake Shore Engineering Co.
Mayo Tunnel & Mine Equip. Co.
Phillips Corp.
Pressed Steel Car Co.
Sanford-Day Iron Works, Inc.
Stephens-Adamson Mfg. Co.
Watt Car & Wheel Co.

CARS, MAN

ACF Industries, Inc.
Bethlehem Steel Co., Inc.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Differential Steel Car Co.
Easton Car & Construction Co.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Irwin Foundry & Mine Car Co.
Kersey Mfg. Co.
Lake Shore Engineering Co.
Lee-Norse Co.
Sanford-Day Iron Works, Inc.
Watt Car & Wheel Co.

CARS, MINE FIRE—also see Fire Fighting Equipment

Enterprise Wheel & Car Corp.
Fyr-Fyter Co.
Gregg Co. Ltd.
Irwin Foundry & Mine Car Co.
Mine Safety Appliances Co.

CARS, ORE, TRANSFER & WASTE

American Car & Foundry Co.
Atlas Car & Mfg. Co.
Bethlehem Steel Co.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Differential Steel Car Co.
Easton Car & Construction Co.
Enterprise Wheel & Car Corp.
Gardner Denver Co.
Gregg Co., Ltd.
Ironton Engine Co.
Irwin Foundry & Mine Car Co.
Kersey Mfg. Co.
Lake Shore Engineering Co.
Maddox Foundry & Machine Wks., Inc.
Mayo Tunnel & Mine Equip. Co.
McNally Pittsburg Mfg. Co.
Morse Bros. Machinery Co.
Phillips Corp.
Pressed Steel Car Co.
Sanford-Day Iron Works, Inc.
Schatz Manufacturing Co.
Stephens-Adamson Mfg. Co.
Treadwell Co., M. H. Inc.
Watt Car & Wheel Co.
Webb Corp.

CARS, SHUTTLE

Dart Truck Co.
Easton Car & Construction Co.
Engineers Syndicate, Ltd.
General Electric Co., Apparatus Sales Div.
Goodman Mfg. Co.
Gregg Co., Ltd.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Lake Shore Engineering Co.

CAR (& LOCOMOTIVE) AXLES

Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Dominion Steel & Coal Corp. Ltd.
Enterprise Wheel & Car Corp.
Flood City Brass & Elec. Co.
Gregg Co., Ltd.
Ironton Engine Co.
Lake Shore Engineering Co.
Phillips Corp.
Pressed Steel Car Co.
Sanford-Day Iron Works, Inc.
U. S. Steel Corp., Columbia Geneva Steel Div.
Watt Car & Wheel Co.

CAR BUMPERS

Card Iron Works Co., C. S.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Irwin Foundry & Mine Car Co.
National Malleable & Steel Castings Co.
Phillips Corp.
Sanford-Day Iron Works Inc.
Watt Car & Wheel Co.
Wellman Engrg. Co.

CAR CAGERS

Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Connellsville Mfg. & Mine Supply Co.
McNally Pittsburg Mfg. Co.
Nolan Co.
Thompson-Starrett Co. Inc., Roberts & Schaefer Co.

CAR COUPLERS

Card Iron Works Co., C. S.
Differential Steel Car Co.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Mayo Tunnel & Mine Equip. Co.
National Malleable & Steel Castings Co.
Ohio Brass Co.
Phillips Corp.
Sanford-Day Iron Works, Inc.
Utility Mine Equip. Co.
Watt Car & Wheel Co.

CAR DERAILERS & RERAILERS

Aldon Co.
American Mine Door Co.
Gregg Co., Ltd.
Miner's Hardware Supply
Nolan Co.
Sanford-Day Iron Works, Inc.

CAR DUMPERS, CROSSOVER & KICKBACK

Card Iron Works Co., C. S.
Gregg Co., Ltd.
Industrial Brownhoist Corp.
Lake Shore Engineering Co.
Link-Belt Co.
Nolan Co.
Webster Mfg., Inc.
West Virginia Steel & Mfg. Co.

CAR DUMPERS, ROTARY

Card Iron Works Co., C. S.
Differential Steel Car Co.
Gregg Co., Ltd.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Lake Shore Engineering Co.
Link-Belt Co.
McKiernan-Terry Corp.
McNally Pittsburg Mfg. Co.
Nolan Co.
Rogers Iron Wks. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Webb Corp.
Wellman Engineering Co.

CAR MOVERS, PULLERS & SPOTTERS

Advance Car Mover Co., Inc.
Aldon Co.
American Mine Door Co.
American Hoist & Derrick Co.
Barium Steel Corp.
Bodinson Mfg. Co.
Clyde Iron Works, Inc.
Connellsville Mfg. & Mine Supply Co.
Christian Engrs., J. D.
Gregg Co., Ltd.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Hough Co., Frank G.
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Joy Mfg. Co.
Ledeen Mfg. Co.
Lidgerwood Industries, Inc.
Link-Belt Co.
McKiernan-Terry Corp.
Nolan Co.
Sanford-Day Iron Works, Inc.
Stamler Co., W. R.
Stephens-Adamson Mfg. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Webster Mfg., Inc.
Western Gear Works

CAR SHAKERS

Allis-Chalmers Mfg. Co.
Hewitt-Robins, Inc.
Link-Belt Co.
Neff & Fry Co.
Simplicity Engineering Co.
Stephens-Adamson Mfg. Co.
Webster Mfg., Inc.

CAR TRANSFERS

American Mine Door Co.

CAR (& LOCOMOTIVE) WHEELS

ACF Industries, Inc.
American Brake Shoe Co.
Armco Steel Corp.
Atlas Car & Mfg. Co.
Barium Steel Corp.
Bethlehem Steel Co.
Bodinson Mfg. Co. Inc.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Differential Steel Car Co.
Enterprise Wheel & Car Corp.
Gregg Co., Ltd.
Irwin Foundry & Mine Car Co.
Lake Shore Engineering Co.
National Malleable & Steel Castings Co.

CAR WHEEL PULLERS

Armstrong-Bray & Co.
Dominion Engineering Co., Ltd.
Gregg Co., Ltd.

CASTINGS, ALUMINUM, BRASS, & OTHER NONFERROUS

Aluminum Co. of America
American Brake Shoe Co.
American Crucible Products Co.
American Hoist & Derrick Co.
Ampco Metal, Inc.
Atlas Foundry Co.
Bethlehem Steel Co.
Brass Foundry Co.
Dominion Engineering Co., Ltd.
Duriron Co., Inc.
Enterprise Wheel & Car Corp.
Flood City Brass & Electric Co.
Franklin Brass Foundry Co.
Gibraltar Equipment & Mfg. Co.
Maddox Foundry & Machine Wks., Inc.
McLanahan & Stone Corp.
Mueller Brass Co.
National Lead Co.
Nordberg Mfg. Co.
Star Brass Works
Stewart-Warner Corp., Alemite Div.
Stoody Co.
Treadwell Engrg. Co.
Weatherly Foundry & Mfg. Co.
Webb Corp.
Wilmot Engineering Co.

CASTINGS, GRAY IRON

American Brake Shoe Co.
American Hoist & Derrick Co.
Bethlehem Steel Co.
Bigelow Liptak Corp.
Calumet & Hecla, Inc.
Card Iron Works Co., C. S.
Carver Pump Co.
Chain Belt Co.
Coeur d'Alene Hardware & Foundry Co.
Consolidated Iron-Steel Mfg. Co.
Continental Gin Co., Industrial Div.
Dominion Engineering Co., Ltd.
Eagle Iron Works
Enterprise Wheel & Car Corp.
Farrel-Birmingham Co.
General American Transportation Co.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Lake Shore Engineering Co.
Link-Belt Co.
Maddox Foundry & Machine Wks., Inc.
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Mine and Smelter Supply Co., Marcy Mill Div.
National Iron Co.
Nordberg Mfg. Co.
Rogers Iron Wks. Co.
Sanford-Day Iron Works, Inc.
Treadwell Engrg. Co.
Warren Foundry & Pipe Corp.
Washington Iron Works
Webb Corp.
Webster Mfg., Inc.
Wilmot Engineering Co.

CASTINGS, MALLEABLE IRON

Dominion Engineering Co., Ltd.
Eimco Corp.
Link-Belt Co.
National Malleable & Steel Castings Co.
Webster Mfg., Inc.

CASTINGS, MANGANESE, MEEHANITE & OTHER FERROUS ALLOYS

American Brake Shoe Co.
Bethlehem Steel Co.
Duriron Co., Inc.
Electric Steel Foundry Co.
Hardinge Co., Inc.
Meehanite Metal Corp.
Mine and Smelter Supply Co., Marcy Mill Div.
McCulloch Motors Corp.
Patten Engrg. Co.
Pettibone Mulliken Corp.
Prescott Co.
Sorel Steel Foundries, Ltd.
Stearns-Roger Mfg. Co.
Straub Mfg. Co.
Taylor-Wharton Iron & Steel Co.
Thomas Foundries, Inc.
Treadwell Engrg. Co.
Victor Equipment Co.
Washington Iron Works

CASTINGS, STEEL

American Hoist & Derrick Co.
American Steel Foundries
Baldwin-Lima-Hamilton Corp.
Bethlehem Steel Co.
Card Iron Works Co., C. S.
Crucible Steel Co.
Eimco Corp.
Electric Steel Foundry Co.
Falk Co.
Farrel-Birmingham Co., Inc.
Gregg Co., Ltd.
Jeffrey Mfg. Co.
Lebanon Steel Foundry
Link-Belt Co.
Los Angeles Steel Casting Co.
Midvale Co.
Mine and Smelter Supply Co., Marcy Mill Div.

National Malleable & Steel Castings Co.
Sorel Steel Foundries, Ltd.
Sterling Steel Casting Co.
Taylor-Wharton Iron & Steel Co.
Treadwell Engrg. Co.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
Vulcan Iron Works (Pa.)
Washington Iron Works

CHAIN, CAST & WELDED
American Brake Shoe Co.
American Chain & Cable Co.
Boston Metals Co., Baldt Anchor Chain & Forge Div.
Bridgeport Chain & Mfg. Co.
Carroll Chain Co.
Cleveland Chain & Mfg. Co.
Flocker & Co., John
National Malleable & Steel Castings Co.
Newhall Chain Forge & Iron Co.
Page Engineering Co.
Ryerson & Son, Inc., J. T.
Taylor Chain Co., S. G.
Woodhouse Chain Works

CHAIN, POWER TRANSMISSION
Chain Belt Co.
Continental Gin Co., Industrial Div.
Diamond Chain Co.
Dodge Mfg. Corp.
Jeffrey Mfg. Co.
Link-Belt Co.
Morse Chain Co.
Webster Mfg., Inc.
Whitney Chain Co.

CHAIN SLINGS
American Chain & Cable Co.
Flocker & Co., John
Ryerson & Son, Inc., J. T.
Taylor Chain Co., S. G.

CHEMICALS & ACIDS—
Also see Flotation Reagents
Allied Chemical & Dye Corp., General Chemical Div.
American Cyanamid Co., Mineral Dressing Div.
American Oil Co.
Armour & Co., Chemical Div.
Baker Chemical Co., J. T.
Braun Corp.
Calcium Chloride Institute
Chemical Construction Corp.
Dow Chemical Co.
du Pont de Nemours & Co., E. I., Grasselli Chemicals Dept.
Eagle-Picher Co.
General Mills, Inc.
Hercules Powder Co.
Koppers Co.
Merck & Co.
Monsanto Chemical Co.
New Jersey Zinc Co., Market Development Div.
Newport Industries, Inc.
Onox, Inc.
Philadelphia Quartz Co.
Pittsburgh Plate Glass Co.
Sharples Chemicals, Inc.
Union Carbide & Carbon Co.
Vitro Corp. of America
Wyandotte Chemicals Corp., Michigan Alkali Div.

CLASSIFIERS—see specific item below, also see Separators

CLASSIFIERS, AIR
Denver Equipment Co.
Dorr-Oliver Inc.
Hardinge Co., Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Ma|ac, Inc.
Sturtevant Mill Co.
Thompson-Starrett Co., Inc.
Roberts & Schaefer Co.
Universal Road Machinery Co.

CLASSIFIERS, BELT
Denver Equipment Co.

CLASSIFIERS, HYDRAULIC
Deister Concentrator Co.
Deister Machine Co.
Denver Equipment Co.
Dorr-Oliver Inc.
Eagle Iron Works
Equipment Engineers, Inc.
Hardinge Co., Inc.
Humphreys Investment Co., Engineering Div.
Mine and Smelter Supply Co., Marcy Mill Div.
Peterson Filters & Engrg. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Western Machinery Co.
Wilmot Engineering Co.

CLASSIFIERS, MECHANICAL
Bodinson Mfg. Co.
Colorado Iron Works
Denver Equipment Co.
Dorr-Oliver Inc.
Hardinge Co., Inc.
Humphreys Investment Co.
Jeffrey Mfg. Co.
Link-Belt Co.
Machinery Center, Inc.
Ma|ac, Inc.
Morse Bros. Machinery Co.
Straub Mfg. Co.
Sturtevant Mill Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Western Machinery Co.

CLOTH, FILTER
Albany Felt Co.
Colorado Fuel & Iron Corp.
Filter Fabrics, Inc.
Ludlow Saylor Wire Cloth Co.
Mt. Vernon-Woodberry Mills, Inc.
Mechanical Industries, Inc.
National Filter Media Corp.
Portland Woolen Mills, Inc.
Stanley Co., Inc., William W.
Turner Halsey Co.
Wellington Sears Co.

CLOTH, INSULATING
Dow Corning Corp.
Minnesota Mining & Mfg. Co., Irvington Varnish & Insulator Div.

CLOTH, WIRE
Cambridge Wire Cloth Co.
Cleveland Wire Cloth & Mfg. Co.
Colorado Fuel & Iron Corp.
Flocker & Co., John
Hewitt-Robins, Inc.
Iowa Mfg. Co.
Ludlow-Saylor Wire Co.
Overstrom & Sons
Simplicity Engineering Co.
Tyler Co., W. S.

CLUTCHES, FLUID—
See Torque Converters

CLUTCHES, FRICTION
Centric Clutch Co.
Conway Clutch Co.
Dodge Mfg. Corp.
Fawick Airflex Co.
Hayes Steel Products, Ltd.
Jeffrey Mfg. Co.
Lee-Norse Co.
Link-Belt Co.
Morse Chain Co.
Twin Disc Clutch Co.
Webster Mfg., Inc.
Wonway Clutch Co.
Yuba Mfg. Co.

CLUTCHES, MAGNETIC
Cutler-Hammer Inc.
Dings Magnetic Separator
Eaton Mfg. Co., Dynamatic Div.
Electric Machinery Mfg. Co.
Magnetic Engrg. & Mfg. Co.
Stearns Magnetic Inc.

COATINGS, CHEMICAL & CORROSION RESISTANT
Industrial Metal Protectives Inc.
Insul-Mastic Corp. of America
Rust-Oleum Corp.
Sika Chemical Corp.
Slip-on, Inc.
Union Carbide & Carbon Corp., National Carbon Co. Div.
Vitro Corp. of America

COMMUNICATIONS, BELL & BUZZER
Auth Electric Co.
Davis Instrument Mfg. Co., Inc.
Graybar Electric Co., Inc.
International Business Machines Corp.
Talk-A-Phone Co.

COMMUNICATIONS, RADIO SYSTEMS
Beckman Instruments, Inc., Berkeley Div.
General Electric Co., Apparatus Sales Div.
Graybar Electric Co., Inc.
Industrial Physics & Electronics Co.
Mine Safety Appliances Co.
Motorola, Communications & Electronics Div.
Radio Corp. of America, Engineering Products Div.
Raytheon Mfg. Co., Belmont Radio Co. Div.
Talk-A-Phone Co.
Westinghouse Electric Corp.

COMMUNICATIONS, TELEPHONES, MINE, TROLLEY & HOIST
Femco Inc.
Graybar Electric Co.
Hose-McCann Telephone Co.
Industrial Physics & Electronics Co.
Mine Safety Appliances Co.
Sperry Corp., Wheeler Insulated Wire Co.
Talk-A-Phone Co.
Western Electric Co.

COMPRESSORS, AIR, PORTABLE
Acme Machinery Co.
American Brake Shoe Co.
Bury Compressor Co.
Cardox Corp.
Chicago Pneumatic Tool Co.
Cooper-Bessemer Corp.
Copco Pacific, Ltd.
Davey Compressor Co.
Gardner-Denver Co.
Imperial Cantrell Mfg. Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Kidde & Company, Inc., Walter
Morse Bros. Machinery Co.
Schramm, Inc.
Westinghouse Air Brake Co., Le Roi Div.
Worthington Corp.

COMPRESSORS, AIR, STATIONARY
Acme Machinery Co.
Allis-Chalmers Mfg. Co.
American Brake Shoe Co.
Bury Compressor Co.
Cardox Corp.
Chicago Pneumatic Tool Co.
Cooper-Bessemer Corp.
Copco Pacific, Ltd.
Dresser Operations, Inc., Clark Bros. Div.
Fuller Co.
Gardner-Denver Co.
General American Transp. Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Kidde & Company, Inc., Walter
Morse Bros. Machinery Co.
Nash Engineering Co.
Pennsylvania Pump & Compressor Co.
Schramm, Inc.
U. S. Hoffman Corp., Air Appl. Div.
Westinghouse Air Brake Co., Le Roi Div.
Worthington Corp.

CONCENTRATORS—see Classifiers or Separators

CONCENTRATING TABLES
Dagley Mfg. Co.
Deister Concentrator Co.
Deister Machine Co.
Denver Equipment Co.
Macklin Equipment Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Morse Bros. Machinery Co.
Straub Mfg. Co.
Sutton, Steele & Steele, Inc.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.

CONCRETE ADDITIVES—also see Freezeproofing Materials
Calcium Chloride Institute
Master Builders Co.
Permagile Corp. of America
Sika Chemical Corp.

CONSULTANTS—See page 218

CONTINUOUS MINERS & PLANERS—also see Cutting Machines
Clarkson Mfg. Co.
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Lee-Norse Co.
Mavor & Coulson Ltd.
Westfalia Lunen
Westinghouse Air Brake Co., Le Roi Div.

CONTROLS, AUTOMATIC, REMOTE & INDICATING
Arrow Hart & Hegeman Electric Co.
Femco Inc.
Industrial Physics & Electronics Co.

CONVEYORS—see specific item below, also see Feeders

CONVEYORS, APRON
American Brake Shoe Co., Amsco Div.
American Conveyor Co.
Barber-Greene Co.
Bodinson Mfg. Co.
Chain Belt Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Heyl & Patterson, Inc.
Hewitt-Robins, Inc.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engrg. Wks.
Marsh Engrg. Co., E. F.
Morse Bros. Machinery Co.
McNally Pittsburg Mfg. Co.
National Iron Co.
Pettibone Mulliken Corp.
Rogers Iron Wks. Co.
Sorel Steel Foundries Ltd.
Stephens-Adamson Mfg. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Universal Engrg. Corp.
Webster Mfg., Inc.
Yuba Mfg. Co.

CONVEYORS, BELT
American Conveyor Co.
Atlas Conveyor Co.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engrs., J. D.
Colorado Fuel & Iron Corp.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Food Machinery & Chemical Corp.
Hewitt-Robins, Inc., Robins Conveyors Div.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Industrial Engrg. & Construction Co.
Iowa Manufacturing Co.
Jeffrey Mfg. Co.
Joy Manufacturing Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Lippmann Engrg. Wks.
Machinery Center, Inc.
Marsh Engineering Co., E. F.
Mayo Tunnel & Mine Equipment Co.
McNally Pittsburg Mfg. Co.
Morse Bros. Machinery Co.
Pettibone Mulliken Corp.
Pioneer Engineering Works, Inc.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
St. Regis Paper Co.
Sturtevant Mill Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Universal Road Machinery Co.
Webb Corp.
Webster Mfg., Inc.
Yuba Mfg. Co.

CONVEYORS (& ELEVATORS), BUCKET
American Brake Shoe Co., American Manganese Steel Div.
American Conveyor Co.
Atlas Conveyor Co.
Barber-Greene Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engrs., J. D.
Columbus Conveyor Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Denver Equipment Co.
Eimco Corp.
Goodman Mfg. Co., Diamond Iron Works Div.
Hewitt-Robins, Inc., Robins Conveyors Div.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Koehring Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engrg. Wks.
Marsh Engineering Co., E. F.
McNally Pittsburgh Mfg. Co.
Pettibone Mulliken Corp.
Rogers Iron Wks. Co.
Stephens-Adamson Mfg. Co.
Sturtevant Mill Co.
Taylor-Wharton Iron & Steel Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Universal Road Machinery Co.
Webb Corp.
Webster Mfg., Inc.
Wilmot Engineering Co.
Yuba Mfg. Co.

CONVEYORS, CHAIN
American Brake Shoe Co., American Manganese Steel Div.
American Conveyor Co.
Atlas Conveyor Co.
Bodinson Mfg. Co., Inc.
Chain Belt Co.
Clarkson Manufacturing Co.
Colorado Fuel & Iron Corp.
Continental Gin Co., Industrial Div.

Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Manufacturing Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kresmer & Sons, Frank A.
Link-Belt Co.
Long Co.
Marsh Engineering Co., E. F.
McNally Pittsburg Mfg. Co.
Prescott Co.
Stephens-Adamson Mfg. Co.
Taylor Chain Co., S. G.
Taylor-Wharton Iron & Steel Co.
Universal Dredge Mfg. Co.
Vulcan Iron Works (Pa.)
Webster Mfg., Inc.
Wilmot Engineering Co.

CONVEYORS, PNEUMATIC
Convair Corp.
Fuller Co.
General American Transp. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Metals Disintegrating Co., Inc., Pulverizing Machinery Div.
U. S. Hoffman Corp., Air Appl. Div.
Westinghouse Electric Corp., Sturtevant Div.

CONVEYORS, PORTABLE
American Conveyor Co.
Athey Products Corp.
Atlas Conveyor Co.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Denver Equipment Co.
Elmco Corp.
Food Machinery & Chemical Corp.
Hewitt-Robins, Inc., Robins Conveyors Div.
Iowa Mfg. Co.
Joy Mfg. Co.
Kresmer & Sons, Frank A.
Lake Shore Engineering Co.
Lippmann Engrg. Wks.
Long Co.
Marsh Engineering Co., E. F.
Pettibone Mulliken Corp.
Pioneer Engineering Works
Rogers Iron Wks. Co.
Stephens-Adamson Mfg. Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.

CONVEYORS, SCRAPER & DRAG
American Conveyor Co.
Atlas Conveyor Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engrs., J. D.
Industrial Engrg. & Construction Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Marsh Engineering Co., E. F.
McNally-Pittsburg Mfg. Corp.
Pettibone Mulliken Corp.
Sauerman Bros., Inc.
Stephens-Adamson Mfg. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Watt Car & Wheel Co.
Webster Mfg., Inc.
Wilmot Engineering Co.

CONVEYORS, SCREW OR SPIRAL
Atlas Conveyor Co.
Baughman Mfg. Co.
Bodinson Mfg. Co.
Central Mine Equipment Co.
Christian Engrs., J. D.
Continental Gin Co., Industrial Div.
Denver Equipment Co.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Link-Belt Co.
Lippmann Engineering Works
McNally Pittsburg Mfg. Co.
Salem Tool Co.
Stephens-Adamson Mfg. Co.
Sturtevant Mill Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Webb Corp.
Webster Mfg., Inc.
Western Machinery Co.

CONVEYORS, SECTIONAL
Barber-Greene Co.
Baughman Mfg. Co.
Christian Engrs., J. D.
Continental Gin Co., Industrial Div.
Food Machinery & Chemical Corp.
Hewitt-Robins, Inc., Robins Conveyors Div.
Jeffrey Mfg. Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engrg. Wks.
Marsh Engrg. Co., E. F.
Stephens-Adamson Mfg. Co.
Universal Dredge Mfg. Co.

CONVEYORS, VIBRATING
Carrier Conveyor Corp.
Goodman Mfg. Co.
Hewitt-Robins, Inc., Robins Conveyors Div.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Joy Mfg. Co.
Lecco Mach. & Engineering Co.
Link-Belt Co.
Overstrom & Sons
Simplicity Engineering Co.
Stephens-Adamson Mfg. Co.
Syntron Co.
Universal Dredge Mfg. Co.

CONVEYOR BELTING
American Rubber Mfg. Co.
American Conveyor Co.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co.
Cincinnati Rubber Mfg. Co.
Colorado Fuel & Iron Corp.
Continental Gin Co., Industrial Div.
Goodall Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins, Inc., Hewitt Rubber Div.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kresmer & Sons, Frank A.
Lee Rubber & Tire Corp., Republic Rubber Div.
Link-Belt Co.
Meckum Engrg. Co.
Minnesota Mining & Mfg. Co., Irvington Varnish & Ins. Div.
New York Belting & Packing Co.
New York Rubber Corp.
Pioneer Rubber Mills
Porter Co., H. K., Quaker Rubber Co. Div.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Scandinavia Belting Co.
Thermoid Co.
U. S. Rubber Co.

CONVEYOR BELTING FASTENERS
American Conveyor Co.
Armstrong-Bray & Co.
Baldwin-Lima-Hamilton Corp.
Carlyle Rubber Co.
Clipper Belt Lacer Co.
Continental Gin Co., Industrial Div.
Crescent Belt Fastener Co.
Hewitt-Robins, Inc.
Iowa Mfg. Co.
Kresmer & Sons, Frank A.
National Mine Service Co.
Talcott, Inc.

CONVEYOR BELTING TAKE-UPS
American Conveyor Co.
Atlas Conveyor Co.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Chain Belt Co.
Continental Gin Co., Industrial Div.
Dodge Mfg. Corp.
Food Machinery & Chemical Corp.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co.
Marsh Engineering Co., E. F.
McNally Pittsburg Mfg. Co.
Meckum Engrg. Co.
Hewitt-Robins, Inc., Robins Conveyors Div.
Stephens-Adamson Mfg. Co.

CONVEYOR BELTING TRIPPERS
Chain Belt Co.
Continental Gin Co., Industrial Div.
Ensign Electric & Mfg. Co.
Hewitt-Robins, Inc., Robins Conveyors Div.
Jeffrey Mfg. Co.
Link-Belt Co.
McNally Pittsburg Mfg. Co.
Stephens-Adamson Mfg. Co.
Universal Engineering Co.

CONVEYOR BELTING VULCANIZERS
Goodrich Co., B. F.
Heintz Mfg. Co.
Hewitt-Robins, Inc., Robins Conveyors Div.
West Virginia Belt & Cable Co.

CONVEYOR IDLERS
American Conveyor Co.
Atlas Conveyor Co.
Barber-Greene Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engrs., J. D.
Continental Gin Co., Industrial Div.
Denver Equipment Co.
Food Machinery & Chemical Corp.
Hewitt-Robins, Inc., Robins Conveyors Div.
Holmes & Bros., Inc., Robert
Iowa Manufacturing Co.
Irwin Foundry & Mine Car Co.
Jeffrey Manufacturing Co.
Joy Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
McNally Pittsburg Mfg. Co.
Meckum Engrg. Co.
Pettibone Mulliken Corp.
Pioneer Engineering Works, Inc.
Prescott Co.
Stephens-Adamson Mfg. Co.
Tool Steel Gear & Pinion Co.
Universal Dredge Mfg. Co.
Universal Engineering Corp.
Webb Corp.
Webster Mfg., Inc.
Yuba Mfg. Co.

CONVERTERS, COPPER
Treadwell Co., M. H. Inc.

COOLERS
Allis-Chalmers Mfg. Co.
American Locomotive Co.
Carrier Corp.
Christian Engrs., J. D.
Condenser Service & Engrg. Co.
Hardinge Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kewanee-Ross Corp.
Link-Belt Co.
Nichols Engineering & Research Corp.
Nordberg Mfg. Co.
Sintering Machinery Corp.
Smidth & Co., F. L.
Traylor Engineering & Mfg. Co.
Webb Corp.
Western Precipitation Corp.
Worthington Corp.

COOLING TOWERS
Carrier Corp.
Foster Wheeler Corp.
Pacific Wood Tank Corp.
Santa Fe Tank & Tower Co.
Wooldridge Mfg. Co.

COUPLINGS, FLEXIBLE
Aeroquip Corp.
Ajax Flexible Coupling Co.
Browning Mfg. Co.
Chain Belt Co.
Chiksan Co.
Continental Gin Co.
De Laval Steam Turbine Co.
Diamond Chain Co.
Dodge Mfg. Corp.
Dominion Engineering Co., Ltd.
Elliott Co.
Falk Corp.
Farrel-Birmingham Co.
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Koppers Co., Inc., Metal Prod. Div.
Link-Belt Co.
Lovejoy Flexible Coupling Co.
Meckum Engrg. Co.
Morse Chain Co.
Philadelphia Gear Works
Poole Foundry & Machine Co.
Thomas Flexible Coupling Co.
Western Gear Works
Whitney Chain Co.

COUPLINGS, FLUID—
Also see Torque Convertors
Carlyle Rubber Co.
Dodge Mfg. Corp.
Link-Belt Co.
Twin Disc Clutch Co.

CRANES, CRAWLER, LOCOMOTIVE & WHEELED
American Hoist & Derrick Co.
American Steel Dredge Co., Inc.
Austin-Western Co.
Baldwin-Lima-Hamilton Corp.
Bay City Shovels, Inc.
Bucyrus-Erie Co.
Clark Equipment Co.
Dominion Engineering Co., Ltd.
Harnischfeger Corp.
Hendrickson Mfg. Co.
Industrial Brownhoist Corp.
Insley Manufacturing Corp.
Koehring Co.
Link-Belt Speeder Corp.
Marion Power Shovel Co.
Northwest Engineering Co.
Ohio Locomotive Crane Co.
Pitman Manufacturing Co.
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
Thew Shovel Co.
Unit Crane & Shovel Corp.

CRANES, JIB
Barium Steel Corp.
Bodinson Mfg. Co., Inc.
Clyde Iron Works, Inc.
Chisholm-Moore Hoist Corp.
Link-Belt Speeder Corp.
Louden Machinery Co.
Magnus, W. R., Inc.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
Northern Engineering Works
Robbins & Meyer, Inc.
Shepard Niles Crane & Hoist Corp.
Treadwell Co., M. H.
Whiting Corp.
Yuba Mfg. Co.

CRANES, TRAVELING, GANTRY & BRIDGE
Austin Western Co.
Barium Steel Corp.
Clyde Iron Works, Inc.
Harnischfeger Corp.
Heyl & Patterson, Inc.
Industrial Brownhoist Corp.
Koehring Co.
Magnus, W. R., Inc.
Manitowoc Engineering Corp.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
McKiernan-Terry Corp.
Reading Crane & Hoist Corp.
Shepard Niles Crane & Hoist Corp.
Treadwell Co., M. H.
Washington Iron Works
Wellman Engineering Co.
Whiting Corp.

CRUSHERS, CONE
Allis-Chalmers Mfg. Co.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Iowa Mfg. Co.
Lippmann Engrg. Wks.
Machinery Center, Inc.
Maddox Foundry & Machine Works
Nordberg Mfg. Co.
Smith Engineering Works

CRUSHERS, DISC
Braun Corp.
Combustion Engineering-Superheater, Inc., Raymond Pulverizer Div.
Denver Fire Clay Co.
Holmes & Bros., Inc., Robert
Mine & Smelter Supply Co.

CRUSHERS, GYRATORY
Allis-Chalmers Mfg. Co.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Dominion Engineering Co., Ltd.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lippmann Engineering Works
Nordberg Mfg. Co.
Smith Engineering Works
Straub Mfg. Co., Inc.

CRUSHERS, HAMMER
Allis-Chalmers Mfg. Co.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Buffalo Hammer Mill Corp.
Holmes & Bros., Inc., Robert
Iowa Manufacturing Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lippmann Engineering Works
Nordberg Mfg. Co.
Pettibone Mulliken Corp.
Rogers Iron Wks. Co.
Sturtevant Mill Co.
Universal Engineering Corp.
Williams Patent Crusher & Pulverizer Co.

CRUSHERS, JAW
Allis-Chalmers Mfg. Co.
Baldwin-Lima-Hamilton Corp.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Denver Equipment Co.
Dominion Engineering Co., Ltd.
Farrel-Birmingham Co., Inc.
Goodman Mfg. Co., Diamond Iron Works Div.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lippmann Engineering Works
Machinery Center, Inc.
McLanahan & Stone Corp.
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Pettibone Mulliken Corp.
Pioneer Engineering Works
Rogers Iron Wks. Co.
Smith Engineering Works
Sturtevant Mill Co.
Traylor Engineering Co.
Universal Engineering Corp.
Universal Road Machinery Co.
Webb Corp.

CRUSHERS, PORTABLE
Athey Products Corp.
Pettibone Mulliken Corp.

CRUSHERS, RING
Bath Iron Works Corp., Pennsylvania Crusher Div.
Buffalo Hammer Mill Corp.
Jeffrey Mfg. Co.
Sturtevant Mill Co.
Williams Patent Crusher & Pulverizer Co.

CRUSHERS, ROLL
Allis-Chalmers Mfg. Co.
Baldwin-Lima-Hamilton Corp.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Colorado Iron Works
Denver Equipment Co.
Dominion Engineering Co., Ltd.
Goodman Mfg. Co., Diamond Iron Works Div.
Heyl & Patterson, Inc.
Iowa Manufacturing Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Lippmann Engineering Works
Maddox Foundry & Machine Works
Metals Disintegrating Co., Inc., Pulverizing Machinery Div.
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Pettibone Mulliken Corp.
Pioneer Engineering Works
Rogers Iron Wks. Co.
Smith Engineering Works
Sturtevant Mill Co.
Traylor Engineering & Mfg. Co.
Universal Engineering Co.
Vulcan Iron Works (Pa.)
Webb Corp.
Williams Patent Crusher & Pulv. Co.
Wilmot Engineering Co.

CRUSHER PARTS
Allis-Chalmers Mfg. Co.
Alloy Steel & Metals Co.
American Brake Shoe Co., American Manganese Steel Div.
Baldwin-Lima-Hamilton Corp.
Bath Iron Works Corp., Pennsylvania Crusher Div.
Dominion Engineering Co., Ltd.
Elmco Corp.
Electric Steel Foundry Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Maddox Foundry & Machine Works
Meckum Engrg. Co.
Pettibone Mulliken Corp.
Smith Engineering Works
Sorel Steel Foundries, Ltd.
Straub Mfg. Co.
Sturtevant Mill Co.
Taylor-Wharton Iron & Steel Co.
Tool Steel Gear & Pinion Co.
Traylor Engrg. & Mfg. Co.
Universal Engrg. Co.
Universal Road Machinery Co.
Webb Corp.

CUTTING MACHINES—also see Continuous Miners & Planers
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.

CUTTING MACHINE BITS
Allegheny Ludlum Steel Corp.
Austin Power Co.
Bowdil Co.
Central Mine Equipment Co.
Cincinnati Mine Machinery Co.
Firth Sterling Inc.
General Electric Co., Carboloy Dept.
Kennametal Inc.
Newcomer Products Inc.,
Savage Co., W. J.
Vascoloy-Ramet Corp.

CUTTING MACHINE PARTS
Allegheny Ludlum Steel Corp.
Bowdil Co.
Central Mine Equipment Co.
Cincinnati Mine Machinery Co.
Precision Chain Co.
Prox Co., Frank
Savage Co., W. J.
Tracy Co., Bertrand P.

CYANIDE—See Chemicals & Acids

CYANIDE PLANTS
Daniels Co. Contractors, Inc.
Dorr-Oliver Co.
Morse Bros. Machinery Co.
Southwestern Engineering Co.
Stearns-Roger Mfg. Co.
Straub Mfg. Co.
Traylor Engineering & Mfg. Co.

CYCLONES
Buell Engineering Co.
Centrifugal & Mech. Ind., Inc.
Daniels Co. Contractors, Inc.
Dorr-Oliver Co.
Ducon Co.
Equipment Engineers, Inc.
General American Transp. Co.
Georgia Iron Works Co.
Heyl & Patterson, Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Mine and Smelter Supply Co., Marcy Mill Div.
McNally Pittsburg Mfg. Co.
Mechanical Industries, Inc.
Northern Blower Co.
Peterson Filters & Engrg. Co.
Simplicity System Co.
Thompson-Starrett Co., Inc.
Roberts & Schaefer Co.

CYLINDERS, AIR & HYDRAULIC
Galland Henning Mfg. Co.
Ledeen Mfg. Co.
New York Air Brake Co.

DENSITY CONTROLLERS
Bristol Co.
Foxboro Co.
Industrial Physics & Electronics Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Nuclear Research Corp.

DIAMONDS
Antwerp Industrial Diamond Co.
Consolidated Diamond Drill Corp.
Diamond Products, Inc.
Hoffman Bros. Drilling Co., Inc.
Koebel Diamond Tool Co.
Mott Core Drilling Co.
Patrick, Inc., R. S.
Smit & Co., Anton
Smit & Sons, Inc., J. K.
Sprague & Henwood, Inc.

DIPPER SHOVELS—See Shovels, Power

DIPPERS, POWER SHOVEL & DREDGE
American Brake Shoe Co., American Manganese Steel Div.
Dominion Engineering Co., Ltd.
Electric Steel Foundry Co.
Marion Power Shovel Co.
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
Sorel Steel Foundries, Ltd.

DRAFTING EQUIPMENT & SUPPLIES
Bruning Co., Inc., Charles
Dietzgen Co., Eugene
Elliot Co., B. K.
Gerber Scientific Instrument Co.
Keuffel & Esser Co.
Post Co., Frederick

DRAGLINES
American Hoist & Derrick Co.
American Steel Dredge Co., Inc.
Baldwin-Lima-Hamilton Corp.
Bay City Shovels, Inc.
Bethlehem Steel Co.
Bucyrus-Erie Co.
Clark Equipment Co., Construction Machinery Div.
Colorado Fuel & Iron Corp.
Dominion Engineering Co., Ltd.
Harnischfeger Corp.
Koehring Co.
Manitowoc Engineering Corp.
Marion Power Shovel Co.
Meckum Engr. Co.
Northwest Engineering Co.
Page Engineering Co.
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
Thew Shovel Co.
Unit Crane & Shovel Corp.

DREDGES
American Steel Dredge Co., Inc.
Bodinson Mfg. Co.
Dominion Steel & Coal Corp., Ltd.
Eagle Iron Works
Georgia Iron Works Co.
Maddox Foundry & Machine Works
Meckum Engineering, Inc.
Morris Machine Works
Universal Dredge Mfg. Co.
Washington Iron Works
Yuba Mfg. Co.

DREDGE SLEEVES
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co.
Goodall Rubber Co.
Hewitt-Robins, Inc.
Meckum Engr. Co.
Morris Machine Works
Quaker Pioneer Rubber Mills
Thermoid Co.
Yuba Mfg. Co.

DRILLS, AUGER
Acker Drill Co., Inc.
Cardox Corp., Hardsocg Div.
Central Mine Equipment Co.
Chicago Pneumatic Tool Co.
Compton Inc.
Dooley Bros.
Gardner-Denver Co.
General Electric Co., Carboloy Dept.
Jeffrey Mfg. Co.
Mayhew Supply Co.
Mobile Drilling Inc.
Salem Tool Co.
Thor Power Tool Co.

DRILLS, BLAST HOLE
Acme Fishing Tool Co.
Boyles Bros. Drilling Co., Ltd.
Bucyrus-Erie Co.
Cardox Corp.
Chicago Pneumatic Tool Co.
Consolidated Diamond Drill Corp.
Drilling Accessory & Mfg. Co., Inc.
Gardner-Denver Co.
General Electric Co., Carboloy Department
Ingersoll-Rand Co.
Joy Mfg. Co.
Longyear Co., E. J.
Mayhew Supply Co.
Mott Core Drilling Co.
Reich Bros. Mfg. Co.
Salem Tool Co.
Schramm, Inc.
Stardrill-Keystone Co.
Thor Power Tool Co.
Winter-Weiss Co.

DRILLS, CHURN
Acme Fishing Tool Co.
Bucyrus-Erie Co.
Consolidated Diamond Drill Corp.
Engineers Syndicate Ltd.
Hossfeld Manufacturing Co.
Longyear Co., E. J.
Stardrill-Keystone Co.

DRILLS, CORE
Acker Drill Co.
Boyles Bros. Drilling Co.
Chicago Pneumatic Tool Co.
Consolidated Diamond Drill Corp.
Drilling Accessory & Mfg. Co.
Hoffman Bros. Drilling Co., Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Koebel Diamond Tool Co.
Longyear Co., E. J.
Mayhew Supply Co.
Mott Core Drilling Co.
Reed Roller Bit Co.
Reich Bros. Mfg. Co.
Sprague & Henwood, Inc.

DRILLS, DIAMOND
Acker Drill Company, Inc.
Boyles Bros. Drilling Co., Ltd. (Canada)
Chicago Pneumatic Tool Co.
Consolidated Diamond Drill Corp.
Diamond Products, Inc.
Hoffman Bros. Drilling Co., Inc.
Joy Mfg. Co.
Koebel Diamond Tool Co.
Longyear Co., E. J.
Metal Carbides Corp.
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Sprague & Henwood, Inc.

DRILLS, FLAME & JET PIERCING
Bucyrus-Erie Co.
Union Carbide & Carbon Corp., Linde Air Products

DRILLS, PERCUSSION
Acme Fishing Tool Co.
Chicago Pneumatic Tool Co.
Copco Ltd.
Gardner-Denver Co.
Hayes Steel Products, Ltd.
Hoffman Bros. Drilling Co., Inc.
Holman Bros., Ltd.
Hossfeld Mfg. Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Stardrill-Keystone Company
Thor Power Tool Co.

DRILLS, PORTABLE ELECTRIC
Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
Cincinnati Electrical Tool Co.
Graybar Elec. Co., Inc.
Hoffman Bros. Drilling Co., Inc.
Homelite Corp.
Jeffrey Mfg. Co.
Syntron Co.
Thor Power Tool Co.

DRILLS, PORTABLE GASOLINE & DIESEL
Boyles Bros. Drilling Co., Ltd.
Cardox Corp.
Engineers Syndicate Ltd.
Hoffman Bros. Drilling Co., Inc.
Hossfeld Manufacturing Co.
Mott Core Drilling Co.
Syntron Co.
Titan Chain Saws, Inc.

DRILLS, ROTARY
Bucyrus-Erie Co.
Cardox Corp.
Chicago Pneumatic Tool Co.
Drilling Accessory & Mfg. Co.
Engineers Syndicate Ltd.
Hoffman Bros. Drilling Co., Inc.
Ingersoll-Rand Co.
Joy Manufacturing Co.
Longyear Co., E. J.
Mayhew Supply Co.
Mott Core Drilling Co.
Reich Bros. Mfg. Co.
Salem Tool Co.
Stardrill-Keystone Company
Thor Power Tool Co.
Winter-Weiss Co.

DRILLS, SHOTHOLE
Acker Drill Company, Inc.
Cardox Corp.
Chicago Pneumatic Tool Co.
Cincinnati Electrical Tool Co.
Consolidated Diamond Drill Corp.
Drilling Accessory & Mfg. Co.
Gardner-Denver Co.
Hoffman Bros. Drilling Co., Inc.
Ingersoll-Rand Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Mott Core Drilling Co.
Reich Bros. Mfg. Co.
Salem Tool Co.
Winter-Weiss Co.

DRILLS, CRAWLER & WHEELED
Bucyrus-Erie Co.
Cardox Corp.
Chicago Pneumatic Tool Co.
Gardner-Denver Co.
Hayes Steel Products, Ltd.
Hoffman Bros. Drilling Co. Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Schramm, Inc.
Stardrill-Keystone Co.
Thor Power Tool Co.
Winter-Weiss Co.

DRILLS, WAGON
Acme Machinery Co.
Chicago Pneumatic Tool Co.
Copco Ltd.
Gardner-Denver Co.
Hayes Steel Products, Ltd.
Hoffman Bros. Drilling Co., Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Schramm, Inc.
Thor Power Tool Co.

DRILL AIRLEGS
Acme Machinery Co.
Chicago Pneumatic Tool Co.
Copco Pacific, Ltd.
Gardner-Denver Co.
Hayes Steel Products, Ltd.
Holman Bros. Ltd.
Ingersoll-Rand Co.
Joy Manufacturing Co.
Thor Power Tool Co.

DRILL ARMS & POSTS
Acme Machinery Co.
Chicago Pneumatic Tool Co.
Dooley Bros.
Hayes Steel Products, Ltd.
Ingersoll-Rand Co.
Joy Mfg. Co.
Thor Power Tool Co.

DRILL BITS, AUGER
Acker Drill Co.
Allegheny Ludlum Steel Corp.
Cardox Corp., Hardsocg Div.
Central Mine Equipment Co.
Compton, Inc.
Dooley Bros.
Firth Sterling, Inc.
Gardner-Denver Co.
General Electric Co., Carboloy Dept.
H & L Tooth Co.
Paris Mfg. Co.
Salem Tool Co.
Thor Power Tool Co.
Vascoloy-Ramet Corp.

DRILL BITS, CHURN
Acme Fishing Tool Co.
Bucyrus-Erie Co.
Spang & Co.
Stardrill-Keystone Co.
U. S. Steel Corp., Oil Well Supply Div.

DRILL BITS, CORE
Acker Drill Co.
Boyles Bros. Drilling Co.
Consolidated Diamond Drill Corp.
Diamond Products, Inc.
Hoffman Bros. Drilling Co., Inc.
Joy Mfg. Co.
Koebel Diamond Tool Co.

Longyear Co., E. J.
Mott Core Drilling Co.
Reed Roller Bit Co.

DRILL BITS, DIAMOND

Acker Drill Co., Inc.
Boyles Bros. Drilling Co., Ltd.
Christensen Diamond Products Co.
Consolidated Diamond Drill Corp.
Diamond Products, Inc.
Gardner-Denver Co.
Hoffman Bros. Drilling Co., Inc.
Koebel Diamond Tool Co.
Joy Mfg. Co.
Longyear Co., E. J.
Metal Carbides Corp.
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Smit & Co., Inc., Anton
Smit & Sons, Inc., J. K.
Sprague & Henwood, Inc.
Thor Power Tool Co.
Wheel Trueing Tool Co.

DRILL BITS, DIAMOND, RESETTING SERVICE

Acker Drill Co.
Boyles Bros. Drilling Co.
Consolidated Diamond Drill Corp.
Hoffman Bros. Drilling Co., Inc.
Joy Manufacturing Co.
Koebel Diamond Tool Co.
Longyear Co., E. J.
Metals Carbides Corp.
Mott Core Drilling Co.
Smit & Sons, Inc., J. K.
Sprague & Henwood, Inc.
Wheel Trueing Tool Co.

DRILL BITS, PERCUSSION

Acme Fishing Tool Co.
Acme Machinery Co.
Allegheny Ludlum Steel Corp.
Brunner & Lay Rock Bit Corp.
Bucyrus-Erie Co.
Gardner-Denver Co.
Hayes Steel Products Co.
Holman Bros., Ltd.
Ingersoll-Rand Co.
Joy Mfg. Co.
Kennametal, Inc.
Stardrill-Keystone Co.
Thompson Products, Ltd.
Thor Power Tool Co.
Throwaway Bit Corp.
Timken Roller Bearing Co.
Vascoloy-Ramet Corp.
Western Rock Bit Mfg. Co.

DRILL BITS, ROTARY

Cardox Corp.
Central Mine Equipment Co.
Copco Pacific, Ltd.
Firth Sterling, Inc.
General Electric Co., Carboloy Dept.
Hawthorne, Inc., Herb J.
Hoffman Bros. Drilling Co., Inc.
Hughes Tool Co.
Joy Mfg. Co.
Mayhew Supply Co.
Mobile Drilling, Inc.
Mott Core Drilling Co.
Reed Roller Bit Co.
Thor Power Tool Co.
Vascoloy-Ramet Corp.

DRILL BIT & STEEL SHARPENERS

Blount Co., J. G.
Chicago Pneumatic Tool Co.
Copco Ltd.
Gardner-Denver Co.
Hoffman Bros. Drilling Co., Inc.
Ingersoll-Rand Co.
Mine & Smelter Supply Co.
Thor Power Tool Co.

DRILL CORE BARRELS

Acker Drill Co.
Boyles Bros. Drilling Co., Ltd.
Christensen Diamond Prod. Co.
Consolidated Diamond Drill Corp.
Hoffman Bros. Drilling Co., Inc.
Joy Manufacturing Co.
Longyear Co., E. J.
Mott Core Drilling Co.
Sprague & Henwood, Inc.

DRILL JUMBOS

Acme Machinery Co.
Chicago Pneumatic Tool Co.
Gardner-Denver Co.
Hayes Steel Products, Ltd.
Ingersoll-Rand Co.
Joy Mfg. Co.
Mayo Tunnel & Mine Equip. Co.
Rogers Iron Wks. Co.
Sanford-Day Iron Works, Inc.
Thor Power Tool Co.
Winter-Weiss Co.

DRILL REAMING STRIPS & SHELLS

Boyles Bros. Drilling Co.
Consolidated Diamond Drill Corp.
Diamond Products, Inc.
Hoffman Bros. Drilling Co., Inc.
Longyear Co., E. J.
Metal Carbides Corp.
Smit & Sons, Inc., J. K.
Wheel Trueing Tool Co.

DRILL STEEL

Acme Machinery Co.
Armco Steel Corp., Sheffield Steel Div.
Atlas Steels, Ltd.
Bethlehem Steel Co.
Brunner & Lay Rock Bit Corp.
Chicago Pneumatic Tool Co.
Coeur d'Alene Hardware & Foundry Co.
Copco
Crucible Steel Co. of America
Gardner-Denver Co.
Hoyland Steel Company, Inc.
Ingersoll-Rand Co.
Thor Power Tool Co.

DRILL STEEL SHARPENERS—
See Drill Bit & Steel Sharpeners

DRILLING CONTRACTORS

Acker Drill Co.
Boyles Bros. Drilling Co.
Consolidated Diamond Drill Corp.
Diamond Drill Contracting Co.
Havlick Diamond Drilling Co.
Hoffman Bros. Drilling Co., Inc.
Joy Mfg. Co.
Judd & Son, J. D.
Longyear Co., E. J.
McDonald Drilling Co.
McKinney Drilling Co.
Minerals Engineering Co.
Mobile Drilling, Inc.
Moore & Siegal
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Southeastern Diamond Drilling Co.
Sprague & Henwood, Inc.
Tinney Drilling Co.

DRIVES—also see Speed Reducers and Torque Convertors

Browning Mfg. Co.
Cleveland Worm & Gear Co.
Dodge Mfg. Corp.
Electric Machinery Mfg. Co.
Falk Corp.
Jones Foundry & Machine Co., W. A.
Link-Belt Co.
Marland One-Way Clutch Co.
Western Gear Works

DRYERS & KILNS—also see Heaters

ACF Industries, Inc.
Bigelow Liptak Corp.
Allis-Chalmers Mfg. Co.
Blue "M" Electric Co.
Bodinson Mfg. Co., Inc.
Christian Engineers, J. D.
Colorado Iron Works
Condenser Service & Engrg. Co.
Denver Equipment Co.
Dorr-Oliver Co.
General American Transportation Corp.
Gould Co., Gordon I.
Hardinge Co., Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Indiana Foundry Co.
Iowa Manufacturing Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Maddox Foundry & Machine Works
McNally Pittsburg Mfg. Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Simplicity System Co.
Smidth & Co., F. L.
Stearns-Roger Mfg. Co.
Thompson-Starrett Co., Roberts & Schaefer Co.
Traylor Engineering & Mfg. Co.
Treadwell Co., M. H.
Universal Dredge Mfg. Co.
Vulcan Iron Works (Pa.)
Webb Corp.
Western Precipitation Corp.
Westinghouse Electric Corp.
Wooldridge Mfg. Co.
Yuba Mfg. Co.

DRYERS, CENTRIFUGAL

Buffalo Forge Co.
Condenser Service & Engrg. Co.
Heyl & Patterson, Inc.
McNally Pittsburg Mfg. Co.
Nichols Engrg. & Research Corp.

DRYERS, ELECTRIC VIBRATING

Albany Felt Co.
Carrier Conveyor Corp.
Jeffrey Mfg. Co.
Link-Belt Co.
Syntron Co.

DUST COLLECTORS

Acme Machinery Co.
American Air Filter Co., Inc.
American Blower Corp.
American Wheelabrator & Equipment Corp.
Barber-Greene Co.
Barium Steel Corp.
Buell Engineering Co.
Buffalo Forge Co.
Chemical Construction Corp.
Cincinnati Electrical Tool Co.
Ducon Co.
Dustex Corp.
Fly Ash Arrestor Corp.
Hardinge Co., Inc.
Heyl & Patterson, Inc.
Iowa Manufacturing Co.
Johnson March Corp.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Koppers Co., Inc.
Majac, Inc.
Mechanical Industries, Inc.
Metals Disintegrating Co., Inc., Pulverizing Machinery Div.
Mine Safety Appliances Co.
National Mine Service Co.
Northern Blower Co.
Pangborn Corp.
Research-Cottrell, Inc.
Simplicity System Co.
Sly Mfg. Co., W. W.
Stearns-Roger Mfg. Co.
Sutton Steele & Steele, Inc.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Turner & Haws Engineering Co.
Universal Dredge Mfg. Co.
Vulcan Iron Works (Pa.)
Western Precipitation Corp.

DUST SAMPLERS

Ducon Co.
Dustex Corp.
Mechanical Industries, Inc.
Mine Safety Appliances Co.
Staplex Co.

ELECTRICAL CONDUIT & FITTINGS—also see Pipe and Tubing

Burndy Engrg. Co., Inc.
Crouse-Hinds Co.
General Electric Co., Construction Materials Div.
Graybar Electric Co.
Johns-Manville
Minnesota Mining & Mfg. Co., Irvington Varnish & Ins. Div.
National Electric Products Corp.
Rome Cable Corp.
Triangle Conduit & Cable Co.

ELECTRICAL CONVERTERS, SYNCHRONOUS

Allis-Chalmers Mfg. Co.
American Machine & Foundry Co., Leland Electric Co. Div.
General Electric Co.
Graybar Elec. Co., Inc.
Reliance Elec. & Eng. Co.
Westinghouse Electric Corp.

ELECTRIC CAP LAMPS

Mine Safety Appliances Co.
National Mine Service Co.

ELECTRIC GENERATORS—Also see Motor-Generator & Engine Generator Sets and Power Plants

Allis-Chalmers Mfg. Co.
Allis Co., Louis
American Machine & Foundry Co., Leland Electric Co. Div.
Baldwin-Lima-Hamilton Corp.
Century Electric Co.
Continental Electric Co.
Electric Machinery Mfg. Co.
Elliott Co., Crocker-Wheeler Div.
Fairbanks, Morse & Co.
General Electric Co.
Graybar Electric Co., Inc.
Hallett Manufacturing Co.
Hobart Brothers
Homelite Corp.
International General Electric Co.
Leach Corp., Palmer Elec. Mfg. Co. Div.
Master Electric Co.
Miehle Printing Press & Mfg. Co., Star-Kimble Motor Div.
Morse Bros. Machinery Co.
National Supply Co.
Onan & Sons, Inc., D. W.
Ready Power Co.
Reliance Electric & Engineering Co.
Robbins & Myers, Inc.
Westinghouse Electric Corp.

ELECTRIC MOTORS

Allis-Chalmers Mfg. Co.
Allis Co., Louis
American Machine & Foundry Co., Leland Electric Co.
Century Electric Co.
Christian Engineers, J. D.
Continental Electric Co.
Diehl Mfg. Co.
Dominion Engineering Co., Ltd.
Electric Machinery Mfg. Co.
Elliott Co. (Ridgway Div.)
Fairbanks, Morse & Co.
General Electric Co.
Graybar Electric Co., Inc.
Lincoln Electric Co.
Link-Belt Co.
Master Electric Co.
Miehle Printing Press & Mfg. Co., Star-Kimble Motor Div.
Moore Co.
Morse Bros. Machinery Co.
Reliance Electric & Engineering Co.
Smith Co., A. O.
Sterling Electric Motors, Inc.
U. S. Electrical Motors, Inc.
Universal Dredge Mfg. Co.
Wagner Electric Corp.
Westinghouse Electric Corp.

ELECTRIC MOTORS, PROTECTED

Allis-Chalmers Mfg. Co.
Allis Co., Louis
American Machine & Foundry Co., Leland Electric Co. Div.
Century Electric Co.
Continental Electric Co.
Diehl Mfg. Co.
Electric Machinery Mfg. Co.
Elliott Co.
Fairbanks, Morse & Co.
General Electric Co.
Graybar Electric Co.
Howell Electric Motors Co.
Lincoln Electric Co.
Master Electric Co.
Miehle Printing Press & Mfg. Co., Star-Kimble Motor Div.
Reliance Electric & Engineering Co.
Robbins & Myers, Inc.
Smith Co., A. O.
U. S. Electrical Motors, Inc.
Universal Dredge Mfg. Co.
Wagner Electric Corp.
Westinghouse Electric Corp.

ELECTRIC MOTOR CONTROLLERS

Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Clark Controller Co.
Cutler-Hammer, Inc.
Durakool, Inc.
Electric Controller & Mfg. Co.
Electric Machinery Mfg. Co.
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
Graybar Electric Co.
Guyan Machinery Co.
Ironton Engine Co.
Jeffrey Mfg. Co.
Ohio Brass Co.
Westinghouse Electric Corp.

ELECTRIC RELAYS

Allis-Chalmers Mfg. Co.
American Mine Door Co.
Cutler-Hammer, Inc.
General Electric Co.
Graybar Electric Co., Inc.
Square D Co.
Westinghouse Electric Corp.
Weston Electrical Instrument Corp.

ELECTRIC SWITCHGEAR & SWITCHES—also see Breakers, Circuit; Brushes, Electrical; Rectifiers; Transformers; and Voltage Regulators

Anderson Mfg. Co., Albert & J. M.
Allis-Chalmers Mfg. Co.
Arrow-Hart & Hegeman Electric Co.
Braun Corp.
Crouse-Hinds Co.
Cutler-Hammer, Inc.
Ensign Electric & Mfg. Co.
Federal Pacific Electric Co.
G & W Electric Specialty Co.
General Electric Co.
Graybar Electric Co., Inc.
I-T-E Circuit Breaker Co.
Post-Glover Electric Co.
Ready Power Co.
Square D Co.
Wagner Electric Corp.
Westinghouse Electric Corp.
Weston Electric Instrument Corp.

ELECTRIC UNIT SUBSTATIONS

Allis-Chalmers Mfg. Co.
Federal Pacific Electric Co.
General Electric Co., Appar. Sales Div.
Graybar Elec. Co., Inc.
Wagner Electric Corp.
Westinghouse Electric Corp.

ENGINES, DIESEL

Allis-Chalmers Mfg. Co.
American Locomotive Co.
Barium Steel Corp.
Baldwin-Lima-Hamilton Corp.
Case Co., J. I.
Caterpillar Tractor Co.
Chicago Pneumatic Tool Co.
Cooper-Bessemer Corp.
Dominion Engineering Co., Ltd.
Dresser Operations, Inc., Clark Bros. Co. Div.
Fairbanks, Morse & Co.

General Motors Corp., Detroit Diesel Engine Div.
Hallett Manufacturing Co.
Harnischfeger Corp.
Hercules Motors Corp.
Ingersoll-Rand Co.
International Harvester Co.
Klockner-Humboldt-Deutz Ag
Murphy Diesel Co.
National Supply Co.
Nordberg Mfg. Co.
Oliver Corp.
Page Engineering Co.
Sheppard Co., R. H.
Waukesha Motor Co.
Worthington Corp.

ENGINES, GAS & GASOLINE
Allis-Chalmers Mfg. Co., Buda Div.
Barium Steel Corp.
Case Co., J. I.
Chrysler Industrial Engine Div.
Cooper-Bessemer Corp.
Cummins Engine Co., Inc.
Dresser Operations, Inc., Clark Bros. Co. Div.
Fairbanks, Morse & Co.
Ford Motor Co.
Gladden Products Corp.
Hercules Motors Corp.
Ingersoll-Rand Co.
International Harvester Co.
National Supply Co.
Nordberg Mfg. Co.
Oliver Corp.
Onan & Sons, Inc., D. W.
Waukesha Motor Co.
Westinghouse Air Brake Co., Le Roi Div.
Worthington Corp.

ENGINES, STEAM
American Hoist & Derrick Co.
Clyde Iron Works, Inc.
Condenser Service & Engineering Co., Inc.
Holmes & Bros., Inc., Robert
McKiernan-Terry Corp.
Nordberg Mfg. Co.
Stearns-Rogers Mfg. Co.
Superior-Lidgerwood-Mundy Corp.

EXPLORATION SERVICE, AERIAL—Also see page 218
Abrams Aerial Survey Corp.
Aero Service Corp.
Ammann Photogrametric Engineers, Inc., Jack
Fairchild Aerial Surveys, Inc.
Hycon Aerial Surveys, Inc.
Longyear Co., E. J.
Minerals Exploration & Research

EXPLORATION SERVICE, GEOLOGICAL—Also see p. 218
Aero Service Corp.
Consolidated Diamond Drill Corp.
Fisher Research Laboratory, Inc.
Longyear Co., E. J.
Lundberg Explorations, Ltd.
Minerals Exploration & Research
Mott Core Drilling Co.

EXPLORATION SERVICE, GEOPHYSICAL—Also see page 218
Aero Service Corp.
Fisher Research Laboratory, Inc.
Hycon Aerial Surveys, Inc.
Longyear Co., E. J.
Lundberg Explorations, Ltd.
Minerals Exploration & Research
Texas Instruments Inc.

EXPLOSIVES—Also see Blasting
American Cyanamid Co., Explosives Dept.
Apache Powder Co.
Atlas Powder Co.
du Pont de Nemours & Co., E. I., Explosives Dept.
Hercules Powder Co.
Illinois Powder Mfg. Co.
King Powder Co.
National Powder Co.
Olin-Mathieson Chemical
Trojan Powder Co.

FANS & BLOWERS
American Blower Corp.
Buffalo Forge Co.
Castle Hills Corp., Hartzell Propeller Fan Co. Div.
Chelsea Fan & Blower Co., Inc.
Clarage Fan Co.
Coppus Engineering Co.
De Laval Steam Turbine Co.
Diamond Power Specialty Co.
Diehl Manufacturing Co.
Dresser Industries Roots-Connersville Blower Div.
Fly Ash Arrestor Corp.
Graybar Electric Co.
Guyan Machinery Co.
Ingersoll-Rand Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Koppers Co., Inc. Metal Products Div.
Moore Co.
Morse Bros. Machinery Co.
New Jersey Meter Co.
Northern Blower Co.
Robbins & Myers, Inc.
Sanford-Day Iron Works Inc.
Sintering Machinery Corp.
U. S. Hoffman Corp., Air Appl. Div.
Westinghouse Electric Corp.

FASTENERS—SCREWS, BOLTS, NUTS, WASHERS, ETC.—also see Rock & Roof Bolts
Elastic Stop Nut Corp. of America
Palnut Co.
Pittsburgh Screw & Bolt Corp.
Security Locknut Corp.
St. Louis Screw & Bolt Co.

FEEDERS—see specific item below, also see Conveyors

FEEDERS, APRON
American Brake Shoe Co., Amsco Div.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Bodinson Mfg. Co.
Christian Engineers, J. D.
Chain Belt Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Denver Equipment Co.
Goodman Mfg. Co., Diamond Iron Works Div.
Hardinge Co., Inc.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Machinery Center, Inc.
Marsh Engineering Co., E. F.
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Morse Bros. Machinery Co.
National Iron Co.
Nordberg Mfg. Co.
Pettibone Mulliken Corp.
Pioneer Engineering Works, Inc.
Roberts & Schaefer Co.
Rogers Iron Wks. Co.
Simplicity System Co.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
Thompson-Starrett Co., Inc.
Traylor Engineering & Mfg. Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Webb Corp.
Webster Mfg., Inc.
Western Machinery Co.

FEEDERS, BELT
American Conveyor Co.
Atlas Conveyor Co.
Barber-Greene Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engineers, J. D.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Dagley Mfg. Co.
Denver Equipment Co.
Hardinge Co., Inc.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
McNally Pittsburg Mfg. Co.
Meckum Engrg. Co.
Merrick Scale Mfg. Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Morse Bros. Machinery Co.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
St. Regis Paper Co.
Universal Dredge Mfg. Co.
Universal Road Machinery Corp.
Webb Corp.
Webster Mfg., Inc.
Western Machinery Co.

FEEDERS, CHAIN
American Conveyor Co.
Atlas Conveyor Co.
Barber-Greene Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engineers, J. D.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kresmer & Sons, Frank A.
Link-Belt Co.
Marsh Engineering Co., E. F.
McNally-Pittsburg Mfg. Co.
Ross Screen & Feeder Co.
Stephens-Adamson Mfg. Co.
Universal Dredge Mfg. Co.
Webster Mfg., Inc.
Whitney Chain Co.

FEEDERS, CONSTANT WEIGHT
Christian Engineers, J. D.
Hardinge Co., Inc.
Hewitt-Robins, Inc.
Jeffrey Mfg. Co.
Merrick Scale Mfg. Co.
Link-Belt Co.
Schaffer Poidometer Corp.
Sintering Machinery Corp.
Stephens-Adamson Mfg. Co.
Syntron Co.

FEEDERS, PAN
Allis-Chalmers Mfg. Co.
Baldwin-Lima-Hamilton Corp.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engineers, J. D.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co.
Goodman Mfg. Co. Diamond Iron Works Div.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert Jeffrey Mfg. Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
McNally Pittsburg Mfg. Co.
Overstrom & Sons
Stephens-Adamson Mfg. Co.
Straub Mfg. Co., Inc.
Taylor-Wharton Iron & Steel Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Webb Corp.
Webster Mfg., Inc.
Western Machinery Co.

FEEDERS, REAGENT—see Reagent Feeders

FEEDERS, RECIPROCATING
American Conveyor Co.
Baldwin-Lima-Hamilton Corp.
Barber-Greene Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engineers, J. D.
Continental Gin Co.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kresmer & Sons, Frank A.
Link-Belt Co.
Lippmann Engineering Works
Marsh Engineering Co., E. F.
McLanahan & Stone Corp.
McNally-Pittsburg Mfg. Co.
Pioneer Engineering Works, Inc.
Rogers Iron Works Co.
Simplicity Engineering Co.
Stearns-Roger Mfg. Co.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co., Inc.
Syntron Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Traylor Engineering & Mfg. Co.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Webster Mfg., Inc.
Williams Patent Crusher & Pulv. Co.

FEEDERS, TABLE
Allis-Chalmers Mfg. Co.
Babcock & Wilcox Co.
Christian Engineers, J. D.
Hardinge Co., Inc.
Link-Belt Co.
Sintering Machinery Corp.
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.

FEEDERS, VIBRATING
Barber-Greene Co.
Carrier Conveyor Corp.
Christian Engineers, J. D.
Continental Gin Co.
Hewitt-Robins, Inc.
Jeffrey Mfg. Co.
Link-Belt Co.
Simplicity Engineering Co.
Stephens-Adamson Mfg. Co.
Syntron Co.
Universal Dredge Mfg. Co.

FILTER MEDIA—also see Cloth, Filter
Albany Felt Co.
Carborundum Co.
Cleveland Wire Cloth & Mfg. Co.
Dagley Manufacturing Co.
Elmco Corp.
Filter Fabrics, Inc.
Filtration Engineers, Inc.
Johns-Manville
Mt. Vernon-Woodberry Mills, Inc.
National Filter Media Corp.
Permutit Co.
Portland Woolen Mills, Inc.
Shriver & Co., Inc., T.
Union Carbide & Carbon Corp., Nat. Carbon Co. Div.
Wellington Sears Co.

FILTERS, AIR
American Air Filter Co., Inc.
American Wheelabrator & Equipment Corp.
Buell Engineering Co.
Copco Pacific, Ltd.
Coppus Engineering Co.
Ducon Co.
Goodyear Tire & Rubber Co.
Johnson-March Corp.
Lincoln Engineering Co.
Mechanical Industries, Inc.
Metals Disintegrating Co., Inc., Pulverizing Machinery Div.
Mine Safety Appliances Co.
Staplex Co., Air Sampler Div.
Thor Power Tool Co.
Turner & Haws Engrg. Co., Inc.
U. S. Hoffman Corp., Air Appl. Div.
Victor Equipment Co.
Westinghouse Electric Corp., Sturtevant Div.
Wilkerson Valve, Inc.

FILTERS, CONCENTRATE
Allis-Chalmers Mfg. Co.
Bird Machine Co.
Dagley Mfg. Co.
Denver Equipment Co.
Dorr-Oliver Co.
Elmco Corp.
Galigher Co.
Machinery Center, Inc.
Morse Bros. Machinery Co.
Peterson Filters & Engineering Co.
Shriver & Co., T.

FILTERS, WATER
Hardinge Co., Inc.
Marvel Engineering Co.
Permutit Co.

FIRE FIGHTING EQUIPMENT & SUPPLIES
Ansul Chemical Co.
Calcium Chloride Institute
Fourwheel Drive Auto Co.
Fyr-Fyter Co.
Grinnell Co., Inc.
Klockner-Humboldt-Deutz Ag.
Mine Safety Appliances Co.
Porto-Pump, Inc.

FIRST AID EQUIPMENT & SUPPLIES
Bullard Co., E. D.
Mine Safety Appliances Co.

FLOOD LIGHTS, CARBIDE
Black Mfg. Co.
MacLeod Co.
Sight Feed Generator Co.

FLOOD LIGHTS, ELECTRIC
Crouse-Hinds Co.
General Electric Co.
Graybar Electric Co.
Homelite Corp.
Mine Safety Appliances Co.
National Mine Service Co.
Onan & Sons, Inc., D. W.
Phoenix Metal Products
Westinghouse Electric Corp.

FLOTATION MACHINES
Bagley Manufacturing Co.
Booth Co.
Denver Equipment Co.
Galigher Co.
General American Transportation Corp.
Machinery Center, Inc.
Mine and Smelter Supply Co., Marcy Mill Div.
Morse Bros. Machinery Co.
Stearns-Roger Mfg. Co.
Western Machinery Co.
Wilmot Engineering Co.

FLOTATION REAGENTS
Allied Chemical & Dye Corp., General Chemical Div.
American Cyanamid Co., Mineral Dressing Dept.

American Gum Products Co.
Armour & Co.
Baker Castor Oil Co.
Baker Chemical Co., J. T.
Ciba Co.
Commercial Solvent Corp.
Denver Equipment Co.
Dewey & Almy Chemical Co.
Dow Chemical Co.
du Pont de Nemours & Co., E. I.
Emery Industries, Inc.
General Mills, Inc.
Hercules Powder Co.
Industrial Oil Products Corp.
Koppers Co., Inc.
Marathon Corp.
Minarec Corp.
Mine and Smelter Supply Co., Marcy Mill Division
Newport Industries, Inc.
Oronite Chemical Co.
Pacific Lumber Co.
Phelps Dodge Refining Corp.
Philadelphia Quartz Co.
Rohm & Haas Co.
Sharples Chemicals, Inc.
Sonneborn Sons, Inc., L.
Stien, Hall & Co., Inc.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Union Carbide & Carbon Corp.
West End Chemical Co.
West Virginia Pulp & Paper Co.

FLOTATION REAGENT FEEDERS—See Reagent Feeders

FORGES, OIL BURNING
Acme Fishing Tool Co.
Buffalo Forge Co.
Gardner-Denver Co.
Hauck Mfg. Co.

FORGINGS, DROP
American Brake Shoe Co.
American Car & Foundry Co.
American Steel Foundries
Barium Steel Corp.
Bethlehem Steel Co.
Cameron Iron Works
Columbus Forge & Iron Co.
Electric Materials Co.
Endicott Forging & Mfg. Co.
Enterprise Wheel & Car Corp.
Hayes Steel Products, Ltd.
Helmick Foundry-Machine Co.
Holmes & Bros., Inc., Robert
Interstate Drop Forge Co.
Ladish Co.
Laughlin Co., Thomas
Midvale Co.
Moore Drop Forging Co.
Ohio Forge & Machine Corp.
Oliver Iron & Steel Corp.
Philadelphia Steel & Iron Co.
Pittsburgh Knife & Forge Co.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
Stearns-Roger Mfg. Co.
Taylor-Wharton Iron & Steel Co.
Transue & Williams Steel Forging Corp.
Upson-Walton Co.

FREEZEPROOFING MATERIALS
Allied Chemical & Dye Corp., Solvay Process Div.
Calcium Chloride Institute
Dow Chemical Co.
International Salt Co.
Master Builders Co.
Morton Salt Co.
Sika Chemical Co.
Wyandotte Chemicals Corp.

FURNACES—see specific item below, also see Heaters

FURNACES, ELECTRIC
Blue "M" Electric Co.
Burrell Corp.
Dominion Engineering Co.
Electrokemisk A. S.
General Electric Co., Apparatus Sales Div.
General Engineering Co., Ltd
Pittsburgh Lectromelt Furnace Corp.
Westinghouse Electric Corp.
Whiting Corp.

FURNACES, MUFFLE
Bellevue Industrial Furnace Co.
Bethlehem Foundry & Machine Co.
Blue "M" Electric Co.
Braun Corp.
Burrell Corp.
General Engrg. Co., Ltd.
Harper Electric Furnace Corp.
Hevi Duty Electric Co.
Hoskins Mfg. Co.
Nichols Engrg. & Research Corp.
Westinghouse Electric Corp.

FURNACES, ROASTING
Allis-Chalmers Mfg. Co.
Blue "M" Electric Co.
Colorado Iron Works Co.
Denver Equipment Co.
Gould Co., Gordon I.
Mace Co.
Nichols Engineering & Research Corp.
Pacific Foundry Co., Ltd.
Stearns-Roger Mfg. Co.
Traylor Engineering & Mfg. Co.

FURNACES, SMELTING
Allis-Chalmers Mfg. Co.
Blue "M" Electric Co.
Colorado Iron Works Co.
Elektrokemisk A. S.
Mace Co.
Nichols Engrg. & Research Corp.
Pacific Foundry Co., Ltd.
Pittsburgh Lectromelt Furnace Corp.
Stearns-Roger Mfg. Co.
Traylor Engineering & Mfg. Co.
Treadwell Co., M. H.

FURNACES, TEMPERING & FORGING
Blue "M" Electric Co.
Bucyrus-Erie Co.
General Electric Co.
General Engineering Co., Ltd.
Hardinge Co., Inc.
Ingersoll-Rand Co.
Westinghouse Electric Corp.

FURNACE LININGS, WALLS & ARCHES—Also see Refractories
Bigelow Liptak Corp.
Reintjes Co., George P.

GAUGES, PRESSURE & VACUUM
Bailey Meter Co.
Braun Corp.
Bristol Co.
Clapp Instrument Co.
Crosby Steam Gauge & Valve Co.
Davis Instrument Mfg. Co., Inc.
Diamond Power Specialty Co.
Foxboro Co.
General Electric Co., Apparatus Sales Div.
Leeds & Northrup Co.
Minneapolis-Honeywell Regulator Co., Brown Instrument Div.
New Jersey Meter Co.
Taylor Instrument Co.
Victor Equipment Co.
Weston Electrical Instrument Corp.

GALVANOMETERS
American Cyanamid Co.
Atlas Powder Co.
Bristol Co.
du Pont de Nemours & Co., E. I. Explosives Dept.
General Electric Co., Apparatus Sales Div.
Hercules Powder Co.
Leeds & Northrup Co.
Trojan Powder Co.
Weston Electrical Instrument Corp.

GAS DETECTORS
Bristol Co.
Mine Safety Appliances Co.
Taller & Cooper, Inc.
U. S. Safety Service Co.
Vitro Corp. of America
Wolf Safety Lamp Co. of America, Inc.

GAS GENERATORS
General Electric Co., Apparatus Sales Div.
Joy Manufacturing Co.
Wellman Engrg. Co.

GASKETS
Carlyle Rubber Co.
Chicago Rawhide Mfg. Co.
Garlock Packing Co.
Goodall Rubber Co.
Greene, Tweed & Co.
Johns-Manville
Keasbey & Mattison Co.
New York Belting & Packing Co.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.

GEARS & PINIONS, METAL
American Brake Shoe Co., American Manganese Steel Div.
American Locomotive Co.
Barium Steel Corp.
Bodinson Mfg. Co.
Brad Foote Gear Works
Christian Engineers, J. D.
Cleveland Worm & Gear Co.
Continental Gin Co., Industrial Div.
Dominion Engineering Co., Ltd.
Falk Corp.
Farrel-Birmingham Co.
Flood City Brass & Electric Co.
Foote Bros. Gear & Machine Corp.
Heyl & Patterson, Inc.
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
McNally Pittsburg Mfg. Co.
Mine and Smelter Supply Co., Marcy Mill Division
Philadelphia Gear Works, Inc.
Pittsburgh Gear Co.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
Sorel Steel Foundries, Ltd.
Stearns-Roger Mfg. Co.
Stroh Process Steel Co.
Tool Steel Gear & Pinion Co.
Vulcan Iron Works (Colo.)
Vulcan Iron Works (Pa.)
Webb Corp.
Webster Mfg., Inc.
Western Gear Works
Westinghouse Electric Corp.
Yuba Manufacturing Co.

GEARS & PINIONS, NON-METALLIC
Brad Foote Gear Works
Dominion Engineering Co., Ltd.
Farrel-Birmingham Co.
Foote Bros. Gear & Machine Corp.
General Electric Co., Apparatus Sales Div.
Jones Foundry & Machine Co., W. A.
Philadelphia Gear Works
Stearns-Roger Mfg. Co.
Western Gear Works
Westinghouse Electric Corp.

GEIGER & SCINTILLATION COUNTERS & RADIATION DETECTORS
Braun Corp.
Beckman Instruments, Inc., Berkeley Scientific Div.
Curtiss-Wright Corp., Electronics Div.
El-Tronics, Inc.
Engineers Syndicate, Ltd.
Fisher Research Laboratory, Inc.
General Nuclear Corp.
Ken Research, Inc.
Menlo Research Laboratory
Nuclear Instrument & Chemical Corp.
Nuclear Research Corp.
Precision Radiation Instruments, Inc.
Radiac Co.
Sherwin Instrument Co., Inc.
Texas Instruments, Inc.
Victoreen Instrument Co.

GEOPHYSICAL INSTRUMENTS
Engineers Syndicate, Ltd.
Fisher Research Laboratory, Inc.
Menlo Research Laboratory
Nuclear Instrument & Chemical Corp.
Precision Radiation Instruments, Inc.
Sherwin Instruments Co.
Texas Instruments, Inc.

GIANTS, HYDRAULIC
Chiksan Co.
Georgia Iron Works Co.

GRADERS, MOTOR
Adams Co., J. D.
Allis-Chalmers Mfg. Co.
Austin Western Co.
Caterpillar Tractor Co.
Galion Iron Works
Pettibone Mulliken Corp.

GRADER BLADES—see Bulldozer & Grader Blades

GRATINGS, FLOOR
Blaw-Knox Co.
Borden Metal Products Co.
Dravo Corp.
Hendrick Mfg. Co.
Inland Steel Co.
Irving Subway Grating Co.
Kerlow Steel Flooring Co.
McNally Pittsburg Mfg. Co.
Smith Co., A. O.
Wheeling Steel Corp.

GRINDERS & BUFFERS, ELECTRIC
Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
Cincinnati Electrical Tool Co.
Graybar Elec. Co., Inc.
Lippmann Engineering Works
New Era Engineering Co.
South Bend Lathe Works
Syntron Co.
Thor Power Tool Co.

GRINDERS & BUFFERS, PNEUMATIC
Chicago Pneumatic Tool Co.
Copco, Ltd.
Ingersoll-Rand Co.
Thor Power Tool Co.

GRINDING WHEELS
Bay State Abrasive Products Co.
Braun Corp.
Carborundum Co.
Copco Pacific, Ltd.
Diamond Products, Inc.
Ingersoll-Rand Co.
Norton Co.
Raybestos-Manhattan, Inc.
Simonds Saw & Steel Co., Simonds Abrasive Co. Div.
Smit & Sons, J. K.
Thor Power Tool Co.

GRIZZLIES
American Brake Shoe Co., American Manganese Steel Div.
Baldwin-Lima-Hamilton Corp.
Bodinson Mfg. Co., Inc.
Carrier Conveyor Corp.
Colorado Fuel & Iron Corp.
Denver Equipment Co.
Hendrick Mfg. Co.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lake Shore Engrg. Co.
Link-Belt Co.
Lippmann Engineering Works
Maddox Foundry & Machine Works
Mine and Smelter Supply Co., Marcy Mill Division
McLanahan & Stone Corp.
National Malleable & Steel Castings Co.
Nordberg Mfg. Co.
Pettibone Mulliken Corp.
Phillips Corp.
Rogers Iron Wks. Co.
Ross Screen & Feeder Co.
Simplicity Engineering Co.
Smith Engineering Works
Stearns-Rogers Mfg. Co.
Straub Mfg. Co., Inc.
Syntron Co.
Traylor Engineering & Mfg. Co.
Tyler Co., The W. S.
Universal Engineering Co.
Webb Corp.
Yuba Mfg. Co.

HARDFACING ALLOYS & RODS—Also see Welding Equipment & Supplies
Alloy Rods Co.
Stoody Co.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
Victor Equipment Co.

HEATERS, SPACE, WATER & DRYING—also see Dryers and Furnaces
American Locomotive Co.
Campbell Co., E. K.
Indiana Foundry Co.
Rust Furnace Co.

HEAT EXCHANGERS
Condenser Service & Engrg. Co.
Kewanee-Ross Corp.

HEAVY MEDIA SEPARATORS
American Cyanamid Co.
Colorado Iron Works Co.
Daniels Company, Contractors, Inc.
Dings Magnetic Separator Co.
Eagle Iron Works
Hardinge Co., Inc.
Jeffrey Mfg. Co.
Link-Belt Co.
Magnetic Engineering & Mfg. Co.
McNally Pittsburg Mfg. Co.
Ore & Chemical Corp.
Southwestern Engineering Co.
Stearns-Roger Mfg. Co.
Tennant Sons & Co., C.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Western Machinery Co.
Wilmot Engineering Co.

HOISTS—see specific item below, also see Winches

HOISTS, CRANE & DERRICK TYPES
American Hoist & Derrick Co.
Barium Steel Corp.
Clyde Iron Works, Inc.
Harnischfeger Corp.
Heyl & Patterson, Inc.
Hyster Co.
Industrial Brownhoist Corp.
Koehring Co.
Lidgerwood Industries, Inc.
Magnus, Inc., W. R.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
McKiernan-Terry Corp.
"Quick-Way" Truck Shovel Co.
Reading Crane & Hoist Corp.
Robbins & Myers, Inc.
Shepard Niles Crane & Hoist Corp.
Treadwell Co., M. H.
Vulcan Iron Works (Pa.)
Yuba Mfg. Co.

HOISTS, HAND CHAIN
Coffing Hoist Co.
Denver Equipment Co.
Harnischfeger Corp.
Magnus, Inc., W. R.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
Morse Bros. Machinery Co.
Reading Crane & Hoist Corp.
Robbins & Myers, Inc.
Vulcan Iron Works (Pa.)
Yale & Towne Mfg. Co.

HOISTS, MONORAIL
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
Reading Crane & Hoist Corp.

Robbins & Myers, Inc.
Shepard Niles Crane & Hoist Corp.
Vulcan Iron Works (Pa.)
Whiting Corp.
Yale & Towne Mfg. Co.

HOISTS, PORTABLE

Chicago Pneumatic Tool Co.
Clyde Iron Works, Inc.
Coffing Hoist Co.
Copco Pacific, Ltd.
Flood City Brass & Electric Co.
Gardner-Denver Co.
Graybar Electric Co., Inc.
Griphoist, Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Lidgerwood Industries, Inc.
Lug-All Co.
Magnus, Inc., W. R.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
Reading Crane & Hoist Corp.
Robbins & Myers, Inc.
Sauerman Bros., Inc.
Shepard Niles Crane & Hoist Co.
Thor Power Tool Co.
Vulcan Iron Works (Colo.)
Vulcan Iron Works (Pa.)

HOISTS, STATIONARY

American Hoist & Derrick Co.
Aros Electric, Inc.
Barium Steel Corp.
Clyde Iron Works, Inc.
Coeur d'Alene Hardware & Foundry Co.
Copco Pacific, Ltd.
Flood City Brass & Electric Co.
Holmes & Bros., Inc., Robert
Ingersoll-Rand Co.
Jones Foundry & Machine Corp.
Joy Mfg. Co.
Lake Shore Engineering Co.
Lidgerwood Industries, Inc.
Link-Belt Co.
Machinery Center, Inc.
Magnus, Inc., W. R.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div.
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Robbins & Myers, Inc.
Rogers Iron Works Co.
Sauerman Bros., Inc.
Shepard Niles Crane & Hoist Corp.
Stearns-Roger Mfg. Co.
Superior-Lidgerwood-Mundy Corp.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Vulcan Iron Works (Colo.)
Vulcan Iron Works (Pa.)
Wellman Engineering Co.
Yuba Mfg. Co.

HOIST CONTROLLERS

Coeur d'Alene Hardward & Foundry Co.
Cutler-Hammer, Inc.
Flood City Brass & Elec. Co.
General Electric Co., Apparatus Sales Div.
Logan Engineering Co.
Vickers, Inc.
Vulcan Iron Works (Pa.)
Yuba Mfg. Co.

HOSE, AIR DRILL, STEAM, WATER

Aeroquip Corp.
American Rubber Mfg. Co.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co.
Chicago Pneumatic Tool Co.
Cincinnati Rubber Mfg. Co.
Copco, Ltd.
Gates Rubber Co.
Goodall Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins, Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Lee Rubber & Tire Corp. Republic Rubber Div.
Lincoln Engineering Co.
Linatex Corp. of America
New York Belting & Packing Co.
Porter Co., H. K., Quaker Rubber Div.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Thermoid Co.
Thor Power Tool Co.
U. S. Rubber Co.

HOSE FITTINGS—CLAMPS, COUPLINGS, SWIVEL JOINTS, ETC.

Aeroquip Corp.
American Rubber Mfg. Co.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Chicago Pneumatic Tool Co.
Chiksan Co.
Commercial Shearing & Stamping, Inc.
Copco, Ltd.
Dixon Valve & Coupling Co.
Goodall Rubber Co.
Hewitt-Robins, Inc.
Hose Accessories Co.
Ingersoll-Rand Co.
Joy Manufacturing Co.
Lincoln Engineering Co.
Punch-Lok Co.
Raybestos-Manhattan, Inc.
Thor Power Tool Co.
Victor Equipment Co.

HUBS, SELECTIVE DRIVE

Warn Mfg. Co.

HYDRAULIC CYLINDERS—see Cylinders, Air & Hydraulic

HYDRAULIC MOTORS

Commercial Shearing & Stamping, Inc.
Diehl Manufacturing Co.
Link-Belt Co.
New York Air Brake Co.
Oliver Iron & Steel Corp.
Vickers, Inc.

HYDRAULIC PUMPS—see Pumps, Hydraulic

HYDRAULIC RAMS

Blackhawk Mfg. Co.
Galland Henning Mfg. Co.
Ledeen Mfg. Co.
New York Air Brake Co.
Templeton, Kenly & Co.

INSULATING COMPOUNDS

Carey Mfg. Co., Philip
Dow Corning Corp.
Eagle-Picher Co.
General Electric Co.
Graybar Electric Co., Inc
Minnesota Mining & Mfg. Co., Irvington Varnish & Insulator Div.
Westinghouse Electric Corp.

INSULATION—also see Cloth, Insulating

Bigelow Liptak Corp.
Carey Mfg. Co., Philip
Dow Corning Corp.
Eagle-Picher Co.
General Electric Co.
Gustin-Bacon Mfg. Co.
Harbison-Walker Refract. Co.
Johns-Manville
Keasbey & Mattison Co.
Minnesota Mining & Mfg. Co., Irvington Varnish & Ins. Div.
Owens-Corning Fiberglass Corp.
Pittsburgh Plate Glass Co.
Talk-A-Phone Co.
Westinghouse Electric Corp.

ION EXCHANGERS

Dorr-Oliver Co.
Permutit Co.

JACKS, LIFTING

Allis-Chalmers Mfg. Co., Buda Div.
Blackhawk Mfg. Co.
Duff-Norton Mfg. Co.
Graybar Electric Co., Inc.
Joyce-Cridland Co.
Star Jack Co.
Templeton, Kenly & Co.
Vulcan Iron Works (Pa.)

JACKS, PULLING

Blackhawk Mfg. Co.
Duff-Norton Mfg. Co.
Graybar Electric Co., Inc.
Joyce-Cridland Co.
Magnus, Inc., W. R.
Templeton, Kenly & Co.

JIGS

Allis-Chalmers Mfg. Co.
Denver Equipment Co.
Dorr-Oliver Co.
Jeffrey Mfg. Co.
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Mine and Smelter Supply Co., Marcy Mill Division
Stearns-Roger Mfg. Co.
Yuba Mfg. Co.

KILNS—See Dryers & Kilns

LABORATORIES—ANALYZING, ASSAYING & TESTING SERVICE
—Also see page 218

Allis-Chalmers Mfg. Co.
American Spectrographic Laboratories
American Cyanamid Co.
Arizona Assay Office
Arizona Testing Laboratories
Beach & Company
Bennetts Chemical Laboratory, Inc.
Black & Deason
California Testing Laboratories, Inc.
Chapman & Wood
Charlton Laboratories
Colorado Assaying Co.
Commercial Testing & Engrg. Co.
Critchett & Ferguson
Custom Assay Office & Laboratory
Deason & Nichols
Denver Equipment Co.
Dickinson Laboratories
Eisenhauer Laboratories
El Paso Testing Laboratories
Engineers Syndicate, Ltd.
Goodall Brothers
Gulick-Henderson Laboratories, Inc.
Hanks, Inc., Abbot A.
Hawley & Hawley
Herman, John
Heyl & Patterson, Inc.
Hill & Jude, Assayers
Jarrell-Ash Co.
Kilby, V. Claiborne
Ledoux & Co., Inc.
Minerals Engineering Co.
Minerals Laboratory
New Mexico Minerals Laboratory
Nuclear Instruments & Chem. Corp.
Pitkin, Inc., Lucius
Root & Simpson, Inc.
Sadtler & Son, Inc.
Sherwin Instruments Co.
Smith-Emery Co.
Snell, Inc., Foster D.
Snyder Mine & Chemical Lab.
Southwestern Engineering Co.
Stowell & Co., W. H.
Sturtevant Mill Co.
Sutton Steele & Steele, Inc.
Tour & Co., Sam
Twining Laboratories
Walker & Whyte, Inc.
Western Machinery Co.
Wood Assaying Co., Henry E.

LABORATORY EQUIPMENT & SUPPLIES

Ainsworth & Sons, Inc., W. M.
Allis-Chalmers Mfg. Co.
Allied Chemical & Dye Corp., General Chemical Div.
Beckman Instruments Co.
Blue "M" Electric Co.
Booth Co.
Braun Corp.
Buffalo Hammer Mill Corp.
Burrell Corp.
Central Scientific Co.
Denver Equipment Co.
Denver Fire Clay Co.
Diamond Products, Inc.
Dominion Engineering Co., Ltd.
Electro Products Lab.
Fisher Scientific Co.
Gallagher Co.
Hardinge Co., Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Menlo Research Laboratory
Mine & Smelter Supply Co.
Norton Co.
Realty & Industrial Corp., Roller Smith Div.
Stearns-Roger Mfg. Co.
Sturtevant Mill Co.
Thompson Balance Co.
Toledo Scale Co.
Torsion Balance Co.
Tyler Co., W. S.
Ultra-Violet Products, Inc.
Universal Vibrating Screen Co.
Voland & Sons, Inc.
Wise Co., O. B.

LAMPS, HEAVY DUTY

Davis Instrument Mfg. Co., Inc.
General Electric Co.

LARRIES & WAGONS

C & D Manufacturing Co.
Connellsville Mfg. & Mine Supply Co.
Differential Steel Car Co.
Webb Corp.
Wooldridge Mfg. Co.

LININGS, ABRASION RESISTANT, - NONMETALLIC

Linatex Corp.
American Rubber Mfg. Co.

LININGS, CORROSION RESISTANT—See Coatings

LIQUID METERS

Bailey Meter Co.
Bristol Co.
Dresser Industries, Roots-Connersville Blower Div.
Esterlein-Angus Co.
Foxboro Co.
Hagan Corp.
Minneapolis-Honeywell Regulator Co., Brown Instrument Div.
New Jersey Meter Co.
Republic Flow Meters Co.
Vitro Corp. of America
Worthington Corp.

LOADERS—see specific item below and also see Shovels, Power

American Tractor Equipment Corp.
Athey Products Corp.
Baker-Raulang Co.
Barber-Greene Co.
Christian Engineers, J. D.
Clark Equipment Co., Construction Machinery Div.
Clarkson Mfg. Co.
Drott Mfg. Co.
Elmco Corp.
Gardner-Denver Co.
Goodman Mfg. Co.
Hough Co., Frank G.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Lee-Norse Co.
Long Co.
McKiernan-Terry Corp.
Myers-Whaley Co.
Pettibone Mulliken Corp.
Stephens-Adamson Mfg. Co.

LOADERS, BOXCAR

Baker-Raulang Co.
Christian Engineers, J. D.
Elmco Corp.
Food Machinery & Chemical Corp.
Hough Co., Frank G.
Morse Bros. Machinery Co.
Ottumwa Box Car Loader Co.
Pettibone Mulliken Corp.
Stephens-Adamson Mfg. Co.

LOADERS, CRAWLER & WHEELED

Allis-Chalmers Mfg. Co., Tractor Div.
Baker-Raulang Co.
Case Co., J. I.
Caterpillar Tractor Co.
Clark Equipment Co., Construction Machinery Div.
Clarkson Manufacturing Co.
Dempster Bros., Inc.
Drott Mfg. Co.
Elmco Corp.
Hough Co., Frank G.
International Harvester Co.
Joy Mfg. Co.
Koehring Co.
Long Co.
Myers-Whaley Co., Inc.
Oliver Corp.
Pettibone Mulliken Corp.
Sheppard Co., Inc., R. H.
Tractomotive Corp.
Westinghouse Air Brake Co., Le Roi Div.

LOADERS, FRONT-END, CRAWLER & WHEELED

Caterpillar Tractor Co.
Clark Equipment Co.
Hough Co., Frank G.
International Harvester Co.

LOADERS, GATHERING ARM OR CHAIN

Clarkson Mfg. Co.
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.

LOADERS, OVERCAST, CRAWLER, RAIL & WHEELED

Elmco Corp.
Gardner-Denver Co.

LOADERS, PORTABLE BELT, BUCKET & CHAIN

American Conveyor Co.
Barber-Greene Co.
Christian Engineers, J. D.
Elmco Corp.
Joy Mfg. Co.
Lake Shore Engineering Co.
Lippmann Engineering Works
Pettibone Mulliken Corp.
Rogers Iron Works Co.
Westinghouse Air Brake Co., Le Roi Div.

LOADERS, SCOOP TYPE

Myers-Whaley Co., Inc.
Sanford-Day Iron Works, Inc.

LOCOMOTIVES, COMPRESSED AIR

Davenport Besler Corp.
Elmco Corp.
Mayo Tunnel & Mine Equip. Co.
Ruth Co.
Universal Dredge Mfg. Co.

LOCOMOTIVES, ELECTRIC BATTERY & TROLLEY

Atlas Car & Mfg. Co.
Differential Steel Car Co.
General Electric Co.
Goodman Mfg. Co., Mancha Storage Battery Locomotive Div.
Greensburg Machine Co.
Ironton Engine Co.
Jeffrey Mfg. Co.
Kersey Mfg. Co.
Morse Bros. Machinery Co.
Vulcan Iron Works (Pa.)

LOCOMOTIVES, GASOLINE, DIESEL, DIESEL-ELECTRIC

American Locomotive Co.
Atlas Car & Mfg. Co.
Baldwin-Lima-Hamilton Corp.
Brookville Locomotive Works
Davenport Besler Corp.
General Electric Co.

Goodman Mfg. Co., Mancha Storage Battery Locomotive Div.
Gregg Co., Ltd.
Klockner-Humboldt-Deutz Ag.
Mayo Tunnel & Mine Equip. Co.
National Mine Service Co.
Ruth Co.
Universal Dredge Mfg. Co.
Vulcan Iron Works (Pa.)

LOCOMOTIVES, STEAM

Davenport Besler Corp.
Vulcan Iron Works (Pa.)

LOCOMOTIVE RESISTORS

Cutler-Hammer, Inc.
General Electric Co.
Guyan Machinery Co.
Post-Glover Electric Co.

LOG WASHERS

Allis-Chalmers Mfg. Co.
Bodinson Mfg. Co.
Christian Engineers, J. D.
Dorr-Oliver Co.
Eagle Iron Works
Georgia Iron Works Co.
Iowa Mfg. Co.
Lippmann Engineering Works
Maddox Foundry & Machine Works
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Pettibone Mulliken Corp.
Sintering Machinery Corp.
Universal Engineering Co.
Webb Corp.
Western Machinery Co.
Yuba Mfg. Co.

LUBRICANTS

American Oil Co.
Ashland Oil & Refining Co.
Atlantic Oil Co.
Cities Service Oil Companies
Continental Oil Co.
D-A Lubricant Co.
Dixon Crucible Co., Joseph
Dow Chemical Co.
Dow Corning Corp.
Esso Standard Oil Co.
Fiske Bros. Refining Co., Lubriplate Div.
Freedom-Valvoline Oil Co.
Gulf Oil Corp.
Houghton & Co., E. F., Hulburt Oil & Grease Co.
Jesco Lubricants Co.
Jet-Lube, Inc.
Keystone Lubricating Co.
New York & New Jersey Lubricant Co.
Ohio Oil Co.
Phillips Petroleum Co.
Pure Oil Co.
Shell Oil Co.
Sinclair Refining Co.
Socony-Vacuum Oil Co.
Standard Oil Co. of California
Standard Oil Co. (Indiana)
Standard Oil Co. of N. J.
Stewart-Warner Corp., Alemite Div.
Sun Oil Co.
Swan-Finch Oil Corp.
Texas Co.
Tide Water Associated Oil Co.
Union Oil Co.
Whitmore Mfg. Co.

LUBRICATING EQUIPMENT

American Oil Co.
Farval Corp.
Frontier Industries, Inc., Manzel Div.
Gray & Co., Inc.
Keystone Lubricating Co.
Lincoln Engineering Co.
Nathan Mfg. Co.
Powell Co., Wm.
Prime Mover
Stewart-Warner Corp., Alemite Div.
Traban Engineering Co.
Victor Equipment Co.

MAGNETS—also see Pulleys, Magnetic and Separators, Magnetic

Austin Western Co.
Batson Electronics Corp., J. A.
Cutler-Hammer, Inc.
Crucible Steel Co. of America
Dings Magnetic Separator Co.
Electric Controller & Mfg. Co.
Eriez Mfg. Co.
General Electric Co., Carboloy Department
Homer Mfg. Co.
Magnetic Engineering & Mfg. Co.
Ohio Electric Mfg. Co.
Stearns Magnetic, Inc.
Sutton Steele & Steele, Inc.

MAPPING, TOPOGRAPHIC, AERIAL & LAND—Also see Exploration Service

Abrams Aerial Survey Corp.
Aero Service Corp.
Jack Ammann Photogrammetric Engrs., Inc.

MILLS, BALL, PEBBLE, ROD & TUBE

Aerofall Mills, Ltd.
Allis-Chalmers Mfg. Co.
Braun Corp.
Denver Equipment Co.
Dominion Engineering Co., Ltd.
Elmco Corp.
Gallagher Co.
Hardinge Co., Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Machinery Center, Inc.
Mine and Smelter Supply Co., Marcy Mill Division
Nordberg Mfg. Co.
Smidth & Co., F. L.
Stearns-Roger Mfg. Co.
Straub Mfg. Co., Inc.
Traylor Engineering & Mfg. Co.
Vulcan Iron Works (Pa.)
Western Machinery Co.

MILL BALLS—See Balls, Grinding

MILL LINERS

Allis-Chalmers Mfg. Co.
American Brake Shoe Co.
Calumet & Hecla, Inc.
Coates Steel Products Co.
Coeur d'Alene Hardward & Foundry Co.
Colorado Fuel & Iron Corp.
Coors Porcelain Co.
Denver Equipment Co.
Dominion Engineering Co., Ltd.
Elmco Corp.
Frog, Switch & Mfg. Co.
Hardinge Co., Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Kensington Steel Co.
Los Angeles Steel Casting Co.
Mine and Smelter Supply Co., Marcy Mill Division
Morse Bros. Machinery Co.
National Malleable & Steel Castings Co.
Sheffield Steel Corp.
Smidth & Co., F. L.
Sorel Steel Foundries, Ltd.
Straub Mfg. Co., Inc.
Taylor-Wharton Iron & Steel Co.
Thomas Foundries, Inc.
U. S. Steel Corp.

MILL RODS

Allis-Chalmers Mfg. Co.
Colorado Fuel & Iron Corp.
Denver Equipment Co.
Dominion Engineering Co., Ltd.
Hardinge Co., Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Mine and Smelter Supply Co., Marcy Mill Div.
Morse Bros. Machinery Co.
Republic Steel Corp.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.

MILL SHELLS

Allis-Chalmers Mfg. Co.
American Brake Shoe Co., American Manganese Steel Div.
American Locomotive Co.
Dominion Engineering Co., Ltd.
Elmco Corp.
Hardinge Co., Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Midvale Co.
Pettibone Mulliken Corp.
Taylor-Wharton Iron & Steel Co.

MINE DOORS, AUTOMATIC

American Mine Door Co.
McKiernan-Terry Corp.

MINERALS, DEALERS & SALES AGENTS

Associated Metals & Minerals Corp.
Brandeis, Goldschmidt & Co., Inc.
Buck Inc., Leonard J.
Continental Ore Corp.
Codey & Co., Inc., E. A.
International Minerals & Metals Corp.
Metal Traders, Inc.
Muller & Co., Inc., Wm. H.
Ore & Chemical Corp.
Overseas Raw Materials Corp.
Philipp Bros., Inc.
Samuels & Co., Inc., Frank
Strauss & Co., Inc., A.
Tennant, Sons & Co., C.
Wah Chang Corp.

MINE SUPPORTS, METAL

Aluminum Co. of America
Armco Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Commercial Shearing & Stamping Co.
Truscon Steel Co.
U. S. Steel Corp.
Wooldridge Mfg. Co.

MOTOR-GENERATOR & ENGINE-GENERATOR SETS—Also see Electric Generators and Power Plants
Allis-Chalmers Mfg. Co., Buda Div.
American Machine & Foundry Co., Leland Electric Co. Div.
General Electric Co.
Leach Corp., Palmer Elec. Mfg. Co. Div.
Mine Safety Appliances Co.
National Supply Co.
Reliance Electric & Engineering Co.
Robbins & Myers, Inc.
Westinghouse Electric Corp.

MUCKING MACHINES—See Loaders

NOZZLES

American Wheelabrator & Equip. Corp.
Bete Fog Nozzle, Inc.
Bin-Dicator Co.
Booth Co.
Brown-Fayro Co.
Carlyle Rubber Co.
Chain Belt Co.
Deister Concentrator Co.
Diester Machine Co.
Fyr-Fyter Co.
Grinnell Co., Inc.
Gundlach Machine Co., T. J.
Hydraulic Supply Mfg. Co.
Iowa Mfg. Co.
Link-Belt Co.
Marley Co.
Meckum Engr. Co.
Nathan Manufacturing Corp.
Norton Co.
Spray Engineering Co.
Victor Equipment Co.
Yarnall-Waring Co.
Yuba Mfg. Co.

ORE SAMPLERS

Allis-Chalmers Mfg. Co.
Dagley Mfg. Co.
Denver Equipment Co.
Ducon Co.
Gallagher Co.
Hardinge Co., Inc.
Ledoux & Co., Inc.
Mine & Smelter Supply Co.
Stearns-Roger Mfg. Co.
Traylor Engineering & Mfg. Co.

PACKING

Boston Woven Hose & Rubber Co.
Carlyle Rubber Co.
Cincinnati Rubber Mfg. Co.
Garlock Packing Co.
Goodall Rubber Co.
Greene, Tweed & Co.
Gulf Oil Corp.
Hewitt-Robins, Inc.
Houghton & Co., E. F.
Johns-Manville
New York Belting & Packing Co.
Porter Co., H. K. Quaker Rubber Co. Div.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Thermoid Co., Indust. Div.
U. S. Rubber Co.

PETROLEUM PRODUCTS—also see Lubricants

Continental Oil Co.
Gulf Oil Corp.
Phillips Petroleum Co.
Shell Oil Co.
Sinclair Refining Co.
Standard Oil Co. of Calif. Western Operating Div.

pH INDICATORS

Allis-Chalmers Mfg. Co.
Analytical Measurements, Inc.
Bailey Meter Co.
Beckman Instrument, Inc.
Braun Corp.
Bristol Co.
Burrell Corp.
Cambridge Instruments, Inc.
Foxboro Co.
Minneapolis-Honeywell Regulator Co. Brown Instrument Div.
Weston Elec. Instrument Corp.

PILLOW BLOCKS & HANGERS

Ahlberg Bearing Co.
Bodinson Mfg. Co.
Chain Belt Co.
Christian Engineers, J. D.
Continental Gin Co., Industrial Div.
Cooper Split Roller Bearing Corp.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Hewitt-Robins, Inc.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Link-Belt Co.
McNally Pittsburg Mfg. Co.
SKF Industries, Inc.
Webster Mfg., Inc.
Wilmot Engineering Co.

PIPE—see specific listing below, also see Electrical Conduit and Tubing, Metal

PIPE, IRON & STEEL

Albert Pipe Supply Co.
American Locomotive Co.
Allegheny Ludlum Steel Corp.
Armco Steel Corp.
Barium Steel Corp.
Bethlehem Steel Co.
Byers Co., A. M.
Colorado Fuel & Iron Corp.
Crucible Steel Co. of America
Dominion Steel & Coal Corp. Ltd.
Duriron Co., Inc.
Electric Steel Foundry Co.
Jones & Laughlin Steel Corp.
Michigan Pipe Co.
National Supply Co.
National Tube Co.
Naylor Pipe Co.
Republic Steel Corp.
Ryerson & Son Inc., Joseph T.
Taylor Pipe & Forge Works
U.S. Pipe & Foundry Co.
U. S. Steel Corp., Columbia-Geneva Steel Div.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
Victaulic Co. of America
Warren Foundry & Pipe Corp.
Wheeling Steel Corp.
Youngstown Sheet & Tube Co.

PIPE, NONFERROUS METAL

Aluminum Co. of America
Ampco Metal, Inc.
Bridgeport Brass Co.
Chase Brass & Copper Co.
National Lead Co.
Revere Copper & Brass Inc.
Reynolds Metals Co.
Triangle Conduit & Cable Co.

PIPE, NONMETALLIC & NON-METALLIC-LINED—also see Pipe, Plastic & Wood

Albert Pipe Supply Co.
American Hard Rubber Co.
Carey Mfg. Co., Philip
Gallagher Co.
Goodall Rubber Co.
Goodyear Tire & Rubber Co.
Hewitt-Robins, Inc.
Johns-Manville
Jones & Laughlin Steel Corp.
Keasbey & Mattison Co.
Linatex Corp. of America
Michigan Pipe Co.
Naylor Pipe Co.
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Union Carbide & Carbon Corp., National Carbon Co. Div.
U. S. Rubber Co.

PIPE, PLASTIC

Albert Pipe Supply Co.
American Hard Rubber Co.
Carlon Products Corp.
Carlyle Rubber Co.
Crane Co.
Dow Chemical Co.
Franklin Plastics Co.
Gates Rubber Company
General Electric Co., Apparatus Sales Div.
Goodall Rubber Co.
Hamilton Rubber Mfg. Corp.
Johnson Plastic Corp.
M & M Woodworking Co.
Minnesota Mining & Mfg. Co., Irvington Varnish & Insulator Div.
Plastex Pipe & Extrusion Co.
Porter Co., H. K., Quaker Rubber Div.
Quaker Pioneer Rubber Mills
Republic Steel Co.
Ryerson & Son, Inc., Joseph T.
Triangle Conduit & Cable Co.
U. S. Rubber Co.
Wellohn Plastics Co., Industrial Div.
Westinghouse Electric Corp.
Yardley Plastics Co.
Youngstown Sheet & Tube Co.

PIPE, VENTILATION—See Ventilation Pipe

PIPE, WOOD

Caldwell Co., W. E.
M & M Woodworking Co.
Michigan Pipe Co.
Santa Fe Tank & Tower Co.
Sutphen, Peter O.

PIPE FITTINGS—Also see Nozzles and Traps

Albert Pipe Supply Co.
Blaw-Knox Co., Power Piping Div.
Catawissa Valve & Fittings Co.
Crane Co.
Dominion Steel & Coal Corp., Ltd.
Dresser Industries, Dresser Mfg. Div.
Duriron Co., Inc.
Electrical Steel Foundry Co.
Fairbanks Company

Grinnell Co., Inc.
Gustin-Bacon Mfg. Co.
Kennedy Valve Mfg. Co.
Ladish Co.
Lunkenheimer Co.
Taylor Forge & Pipe Works
Victaulic Co. of America
Walworth Co.
Warren Foundry & Pipe Corp.
Yardley Plastics Co.

PLANT DESIGN & CONSTRUCTION—Also see page 218

Allen & Garcia Co.
Arrowhead Steel Buildings, Inc.
Booth Engineers
Chemical Construction Corp.
Daniels Company, Contractors, Inc.
Davis Co., Nelson L.
Denver Equipment Co.
Dorr-Oliver, Inc.
Fairmont Machinery Co.
Fitz Simons & Connell Dredge & Dock Co.
Foster Wheeler Corp.
Galigher Company
Heyl & Patterson, Inc.
Isbell Construction Co.
Jeffrey Mfg. Co.
Kaiser Engineers
Klockner-Humboldt-Deutz Ag., c/o Diesel Energy Corp.
Link-Belt Co.
Mace Co.
McGraw Co., F. H.
McNally Pittsburg Mfg. Co.
Minerals Engineering Co.
Nichols Engineering & Research Corp.
Parsons Co., Ralph M.
Peterson Filters & Engrg. Co.
Southwestern Engineering Co.
Stearns-Roger Mfg. Co.
Thompson-Starrett Co., Inc.,
Universal Dredge Mfg. Co.
Vitro Corp. of America
Walvoord, Inc., O. W.
Western-Knapp Engineering Co.
Western Machinery Co.

POWER PLANTS—Also see Electric Generators and Motor-Generator & Engine-Generator Sets

American Locomotive Co.
Arrowhead Steel Buildings, Inc.
Condenser Service & Engrg. Co.
Denver Equipment Co.
Foster Wheeler Corp.
General Electric Co.
Hobart Brothers
International Harvester Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Lincoln Electric Co.
Miller Electric Mfg. Co.
Nordberg Manufacturing Co.
Ready Power Co.
Stearns-Roger Mfg. Co.
Westinghouse Electric Corp.

POWER TAKE-OFFS—Also see Drives

Hayes Steel Products, Ltd.
Hendrickson Mfg. Co.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
Twin Disc Clutch Co.
Western Gear Works

PROFESSIONAL SERVICES—See page 218

PULLEYS, IRON, STEEL & WOOD—Also see Blocks & Sheaves, and Sheaves

American Hoist & Derrick Co.
American Pulley Co.
Bodinson Mfg. Co.
Christian Engineers, J. D.
Continental Gin Co.
Dodge Manufacturing Corp.
Ensign Electric & Mfg. Co.
Gates Rubber Co.
Hewitt-Robins, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Manufacturing Co.
Jones Foundry & Machine Co., W. A.
Link-Belt Co.
Lippmann Engineering Works
McNally Pittsburg Mfg. Co.
National Iron Co.
Reeves Pulley Co.
Stephens-Adamson Mfg. Co.
Webb Corp.
Webster Mfg., Inc.
Yuba Mfg. Co.

PULLEYS, MAGNETIC—Also see Separators, Magnetic

Continental Gin Co.
Cutler-Hammer, Inc.
Dings Magnetic Separator Co.
Electric Controller & Mfg. Co.
Erie Mfg. Co.
Hewitt-Robins, Inc.
Homer Mfg. Co.
Industrial Physics & Electronics Co.
Jeffrey Mfg. Co.
Magnetic Engineering & Mfg. Co.
Ohio Electric Mfg. Co.
Stearns Magnetic, Inc.
Stearns-Roger Mfg. Co.

PULVERIZERS

Babcock & Wilcox Co.
Combustion Engineering, Inc.
Hardinge Co., Inc.
Majac, Inc.
Metals Disintegrating Co., Inc., Pulverizing Machinery Div.
Stearns-Roger Mfg. Co.
Whiting Corp.
Williams Patent Crusher & Pulverizer Co.

PUMPS, AIR DRIVEN

Acme Machinery Co.
Byron Jackson Co.
Chicago Pneumatic Tool Co.
Davidson Co., M. T.
Dorr-Oliver, Inc.
Gardner-Denver Co.
Lincoln Engrg. Co.
Stewart-Warner Corp., Alemite Div.
Warren Steam Pump Co.

PUMPS, CENTRIFUGAL & TURBINE

Ampco Metal, Inc.
Barnes Mfg. Co.
Barrett Haentjens & Co.
Byron Jackson Co.
Carver Pump Co.
Chain Belt Co.
Davidson Co., M. T.
De Laval Steam Turbine Co.
Deming Co.
Dominion Engineering Co., Ltd.
Duriron Co., Inc.
Fairbanks, Morse & Co.
Food Machinery & Chemical Corp.
Gardner-Denver Co.
Gorman-Rupp Co.
Goulds Pumps, Inc.
Goyne Steam Pump Co.
Homelite Corp.
Ingersoll-Rand Co.
LaBour Co.
Layne & Bowler, Inc.
Lecourtenay Co.
Maddox Foundry & Machine Works
McNally Pittsburg Mfg. Co.
Mission Mfg. Co.
Morris Machine Works
New York Air Brake Co., Aurora Pump Div.
Prescott Co.
Smith Co., A. O.
Thomas Foundries, Inc.
Titan Chain Saws, Inc.
Warren Steam Pump Co.
Western Machinery Co.
Wilfley & Sons, Inc., A. R.
Worthington Corp.

PUMPS, CORROSIVE LIQUIDS

Dorr-Oliver, Inc.
Duriron Co., Inc.
Goulds Pumps, Inc.
Linatex Corp. of America
Nagle Pumps, Inc.
Wilfley & Sons, Inc., A. R.

PUMPS, HYDRAULIC

Blackhawk Mfg. Co.
New York Air Brake Co., Hydraulic Div.
Oliver Iron & Steel Corp.
Vickers, Inc.

PUMPS, MINE & DEEP WELL

Allis-Chalmers Mfg. Co.
Barrett Haentjens & Co.
Chicago Pneumatic Tool Co.
Davidson Co., M. T.
Deming Co.
Fairbanks-Morse & Co.
Flood City Brass & Elec. Co.
Food Machinery & Chemical Corp.
Gorman-Rupp Co.
Goyne Steam Pump Co.
Ingersoll-Rand Co.
Johnston Pump Co.
LaBour Co., Inc.
Lane & Bowler, Inc.
Lecourtenay Co.
Morris Machine Works
New York Air Brake Co., Aurora Pump Div.
Rice Pump & Machine Co.
Robbins & Myers, Inc.
Sanford-Day Iron Works, Inc.
Warren Steam Pump Co.
Webb Corp.

PUMPS, PISTON & PLUNGER

Boyles Bros. Drilling Co., Ltd.
Davidson Co., M. T.
Deming Co.
Dorr-Oliver, Inc.
Fairbanks, Morse & Co.
Flood City Brass & Electric Co.
Gardner-Denver Co.
Goulds Pumps, Inc.
Goyne Steam Pump Co.
Ledeen Mfg. Co.
Lincoln Engineering Co.
New York Air Brake Co.
Prescott Co.
Warren Steam Pump Co.

PUMPS, PRIMING

Barrett Haentjens & Co.
Dresser Industries, Roots Connersville Blower Div.
Fairbanks, Morse & Co.
Goyne Steam Pump Co.

PUMPS, ROTARY DISPLACEMENT

Chicago Pneumatic Tool Co.
De Laval Steam Turbine Co.
Dresser Industries, Roots-Connersville Blower Div.
Porta-Pump, Inc.
Robbins & Myers, Inc.
Warren Steam Pump Co.
Worthington Corp.

PUMPS, SAND & SLIME

Allen-Sherman-Hoff Pump Co.
Allis-Chalmers Mfg. Co.
American Brake Shoe Co., American Manganese Steel Div.
Barnes Mfg. Co.
Barrett Haentjens & Co.
Dagley Mfg. Co.
Denver Equipment Co.
Dorr-Oliver, Inc.
Galigher Co.
Georgia Iron Works Co.
Gorman-Rupp Co.
Goulds Pumps, Inc.
Linatex Corp. of America
Machinery Center, Inc.
Maddox Foundry & Machine Works
McNally Pittsburg Mfg. Co.
Mine and Smelter Supply Co., Marcy Mill Division
Morris Machine Works
Nagle Pumps, Inc.
Pettibone Mulliken Corp.
Robbins & Myers, Inc.
Taylor-Wharton Iron & Steel Co.
Thomas Foundries, Inc.
Universal Dredge Mfg. Co.
Western Machinery Co.
Wilfley & Sons, Inc., A. R.
Yuba Mfg. Co.

PUMPS, SUMP

Allis-Chalmers Mfg. Co.
Barnes Mfg. Co.
Barrett Haentjens & Co.
Byron-Jackson Co.
Chicago Pneumatic Tool Co.
Dagley Mfg. Co.
Davidson Co., M. T.
Deming Co.
Dorr-Oliver, Inc.
Fairbanks, Morse & Co.
Food Machinery & Chemical Corp.
Galigher Co.
Gardner-Denver Co.
Gorman Rupp Co.
Goulds Pumps, Inc.
Ingersoll-Rand Co.
Johnston Pump Co.
Layne & Bowler, Inc.
McNally Pittsburg Mfg. Co.
Morris Machine Works
Nagle Pumps, Inc.
New York Air Brake Co., Aurora Pump Div.
Reed Roller Bit Co.
Robbins & Myers, Inc.
Schramm, Inc.
Thor Power Tool Co.
Titan Chain Saws, Inc.
Warren Steam Pump Co.
Worthington Corp.
Yuba Mfg. Co.

PUMPS, VACUUM

Allis-Chalmers Mfg. Co.
Barrett Haentjens & Co.
Braun Corp.
Chicago Pneumatic Tool Co.
Davidson Co., M. T.
Denver Equipment Co.
Dorr-Oliver, Inc.
Dresser Industries, Roots-Connersville Blower Div.
Fuller Co.
Gardner-Denver Co.
Ingersoll-Rand Co.
Nash Engrg. Co.
New York Air Brake Co.
Pennsylvania Pump & Compressor Co.
Robbins & Myers, Inc.
Worthington Corp.

PUMP DIAPHRAGMS

Carlyle Rubber Co.
Carver Pump Co.
Dagley Mfg. Co.
Denver Equipment Co.
Dorr-Oliver, Inc.
Garlock Packing Co.
Goodall Rubber Co.
Gorman Rupp Co.
Morse Bros. Machinery Co.
New York Belting & Packing Co.
Porter Co., H. K., Quaker Rubber Div.
Rice Pump & Machine Co.
Shriver & Co., Inc., T.
U. S. Rubber Co., Mech. Gds. Div.

PYROMETERS

Bailey Meter Co.
Braun Corp.
Bristol Co.
Foxboro Co.
General Electric Co.
Leeds & Northrup Co.
Weston Elec. Instrument Corp.

RADIATION DETECTORS—See Gieger Counters

RAIL & TRACK

Bethlehem Steel Co.
Card Iron Works Co., C. S.
Colorado Fuel & Iron Corp.
Dominion Steel & Coal Corp., Ltd.
Foster Co., L. B.
Gregg Co., Ltd.
Inland Steel Co.
Morse Bros. Machinery Co.
Ryerson & Son, Inc., J. T.
Sweet's Steel Co.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.

RAIL & TRACK ACCESSORIES—See specific item under Rail . . . or Track . . .

RAIL BENDERS

Aldon Co.
Allis-Chalmers Mfg. Co., Buda Div.
Card Iron Works Co., C. S.
Gibraltar Equipment & Mfg. Co.
Gregg Co., Ltd.
Utility Mine Equipment Co.
Watt Car & Wheel Co.
West Virginia Steel & Mfg. Co.

RAIL BONDS

Ensign Electric & Mfg. Co.
Erico Products, Inc.
Ohio Brass Co.
U. S. Steel Corp., Amer. Steel & Wire Div., & Columbia-Geneva Steel Div.

RAIL BRACES

American Brake Shoe Co.
Bethlehem Steel Co.
Card Iron Works Co., C. S.
Gregg Co., Ltd.
Pettibone Mulliken Corp.
Taylor-Wharton Iron & Steel Co.
U. S. Steel Co., Columbia-Geneva Steel Div.
Weir Kilby Corp.
West Virginia Steel & Mfg. Co.

RAIL CLAMPS

Bethlehem Steel Co.
Gregg Co., Ltd.
Heyl & Patterson, Inc.
Taylor-Wharton Iron & Steel Co.
U. S. Steel Corp.
Weir Kilby Corp.
West Virginia Steel & Mfg. Co.

RAIL DRILLS & PUNCHES

Gregg Co., Ltd.
Mine Safety Appliances Co.
Nordberg Mfg. Co.
Utility Mine Equipment Co.

RAIL FISH PLATES

Colorado Fuel & Iron Corp.
Gregg Company, Ltd.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.

RAIL FROGS, SWITCHES, & CROSSINGS

American Brake Shoe Co.
Bethlehem Steel Co.
Card Iron Works Co., C. S.
Foster Co., L. B.
Gibraltar Equipment & Mfg. Co.
Gregg Co., Ltd.
Miners Hardware Supply Co.
Nolan Co.
Pettibone Mulliken Corp.
Taylor-Wharton Iron & Steel Co.
U. S. Steel Corp.
Weir Kilby Corp.
West Virginia Steel & Mfg. Co.

RAIL SIGNALS

American Mine Door Co.
Gregg Co., Ltd.
Miners Hardware Supply Co.
U. S. Steel Corp.

RAIL SPIKES

American Brake Shoe Co.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Dominion Steel & Coal Corp., Ltd.
Foster Co., L. B.
Gregg Co., Ltd.
Inland Steel Co.
Jones & Laughlin Steel Corp.
Oliver Iron & Steel Corp.
Republic Steel Corp.
Sheffield Steel Corp.

U. S. Steel Corp., Amer. Steel & Wire Div.
West Virginia Steel & Mfg. Co.
Youngstown Sheet & Tube Co.

RAIL TIE PLATES

Bethlehem Steel Co.
Central Frog & Switch Co.
Colorado Fuel & Iron Corp.
Dominion Steel & Coal Corp., Ltd.
Foster Co., L. B.
Gregg Co., Ltd.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.

RAIL TIES, STEEL

Bethlehem Steel Co.
Central Frog & Switch Co.
Colorado Fuel & Iron Corp.
Gregg Co., Ltd.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.
Wooldridge Mfg. Co.

RAIL TURNTABLES

Atlas Car & Mfg. Co.
Card Iron Works Co., C. S.
Easton Car & Construction Co.
Gregg Co., Ltd.

REAGENT FEEDERS

American Cyanamid Co., Mineral Dressing Dept.
Clarkson Co.
Coeur d'Alene Hardware & Foundry Co.
Dagley Mfg. Co.
Denver Equipment Co.
Deister Concentrator Co.
Deister Machine Co.
Frontier Industries, Inc., Manzel Div.
Fuller Co.
Galigher Co.
Jeffrey Mfg. Co.
Mine and Smelter Supply Co., Marcy Mill Division
Savage Co., W. J.
Stearns-Roger Mfg. Co.
Syntron Co.

RECTIFIERS, MERCURY ARC

Allis-Chalmers Mfg. Co.
General Electric Co.
Magnetic Engineering & Mfg. Co.
Reliance Elec. & Eng. Co.

RECTIFIERS, SELENIUM

Allis-Chalmers Mfg. Co.
Electro Products Lab.
General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
Graybar Elec. Co., Inc.
Magnetic Engineering & Mfg. Co.
Mine Safety Appliances Co.
Smith Co., A. O.
Syntron Co.
Westinghouse Electric Corp.

REDUCERS, SPEED—See Speed Reducers

REFRACTORIES

Babcock & Wilcox Co.
Carborundum Co., Refractory Div.
Denver Fire Clay Co.
Electro Refractories & Abrasives Corp.
General Refractories Co.
Green Fire Brick Co., A. P.
Harbison-Walker Refractories Co.
Johns-Manville
Mexico Refractories Co.
Mullite Refractories Co.
North American Refractories Co.
Norton Co.
Porter Co., H. K., Laclede Christy Co. Div.
Union Carbide & Carbon Corp., National Carbon Co. Div.
Walsh Refractories Corp.

REFRACTORY CEMENT

Babcock & Wilcox Co.
Carborundum Co., Refractory Div.
Carey Mfg. Co., Philip
Dixon Crucible Co., Joseph
Eagle-Picher Co.
Electro Refractories & Abrasives Corp.
General Refractories Co.
Green Fire Brick Co., A. P.

RESPIRATORS—See Safety Respirators

ROCK (& ROOF) BOLTS

Arro Expansion Bolt Co.
Barium Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Dominion Steel & Coal Corp., Ltd.
Elreco Corp.
Hayes Steel Products, Ltd.
Ohio Brass Co.
Oliver Iron & Steel Corp.
Patton Mfg. Co., Inc.
Pittsburgh Screw & Bolt Corp.
Republic Steel Corp.
Ryerson & Son, Inc., J. T.
Sheffield Steel Corp.
Star Expansion Bolt Co.
St. Louis Screw & Bolt Co.
West Virginia Steel & Mfg. Co.
Youngstown Sheet & Tube Co.

ROOF BOLTING MACHINES

Acme Machinery Co.
Baker-Raulang Co., Indus. Truck Div.
Chicago Pneumatic Tool Co.
Continental Gin Co., Indus. Div.
Joy Mfg. Co.
Lee-Norse Co.
Oliver Iron & Steel Corp.

ROOFING & SIDING, METAL

Aluminum Co. of America
Armco Steel Corp.
Bethlehem Steel Co.
Butler Mfg. Co.
Illinois Zinc Co.
Mahon Co., R. C.
New Jersey Zinc Co.
Plasteel Products Corp.
Republic Steel Corp.
Revere Copper & Brass, Inc.
Reynolds Metals Co.
Robertson Co., H. H.
U. S. Steel Corp.
Wheeling Steel Corp.
Youngstown Sheet & Tube Co.

ROOFING & SIDING, NONMETALLIC

Carey Mfg. Co., Philip
Flintkote Co.
Johns-Manville
Keasbey & Mattison Co.
Ruberoid Co.

RUST PREVENTATIVES

American Wheelabrator & Equip. Corp.
Houghton & Co., E. F.

SAFETY CLOTHING, HATS, BELTS, & SHOES

American Optical Co.
Bullard Co., E. D.
Goodall Rubber Co.
Industrial Gloves Co.
International Shoe Co.
Johns-Manville
Keasbey & Mattison Co.
Lehigh Safety Shoe Co.
Mine Safety Appliances Co.
Mitchell Mfg. Co.
Parker Safety Equipment Co.
Penn Mfg. & Supply Co.
Pulmosan Safety Equipment Corp.
Riegel Textile Corp.
Safety Clothing & Equipment Co.
Safety First Shoe Co.
Safety First Supply Co.
U. S. Safety Service Co.
Welsh Mfg. Co.
Willson Products, Inc.

SAFETY GOGGLES & MASKS

American Optical Co.
Bausch & Lomb Optical Co.
Bullard Co., E. D.
Chicago Eye Shield Co.
Goggle Parts Co.
Mine Safety Appliances Co.
Pulmosan Safety Equipment Corp.
U. S. Safety Service Co.
Welsh Mfg. Co.
Willson Products, Inc.

SAFETY RESPIRATORS

American Optical Co.
Bullard Co., E. D.
Chicago Eye Shield Co.
Mine Safety Appliances Co.
Pulmosan Safety Equipment Corp.
Safety First Supply Co.
Willson Products, Inc.

SAND WASHING PLANTS

Bodinson Mfg. Co.
Colorado Iron Works
Conveyor Co.
Deister Machine Co.
Denver Equipment Co.
Dorr-Oliver, Inc.
Eagle Iron Works
Goodman Mfg. Co., Diamond Iron Works Div.
Gruendler Crusher & Pulverizer Co.
Iowa Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lippmann Engineering Works
Maddox Foundry & Machine Works
Pettibone Mulliken Corp.
Pioneer Engineering Works
Smith Engineering Works
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Universal Road Machinery Co.
Universal Engineering Co.
Yuba Mfg. Co.

SAWS

Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
Disston & Sons, Inc., Henry
General Steel Warehouse Co., Inc., Gensco Tools Div.
Homelite Corp.
Ingersoll-Rand Co.
Lippmann Engrg. Works
Lombard Governor Corp.
Simonds Saw and Steel Co.
Stanley Works, Stanley Electric Tool Div.
Thor Power Tool Co.
Titan Chain Saws, Inc.
U. S. Electrical Tool Co.
Vulcan Iron Works (Colo.)
Wright Power Saw & Tool Corp.

SCALES, AUTOMATIC WEIGHING

Aerofall Mills, Ltd.
Builders-Providence, Inc.
Chatillon & Sons, John
Conveyor Co.
Cox & Stevens Electronic Scales
Fairbanks, Morse & Co.
Howe Scale Co., Inc.
Industrial Physics & Electronics Co.
Koehring Co.
Merrick Scale Mfg. Co.
Schaffer Poidometer Co.
Sintering Machy. Corp.
Streeter-Amet Co.
St. Regis Paper Co.
Taller & Cooper, Inc.
Thurman Machine Co.

SCALES, PLATFORM

Cox & Stevens Electronic Scales
Fairbanks, Morse & Co.
Howe Scale Co.
Koehring Co.
Magnus, Inc., W. R.
Stamler Co., W. R.
Taller & Cooper, Inc.
Thurman Machine Co.
Toledo Scale Co.
Webb Corp.
Yale & Towne Mfg. Co.

SCALES, SACKING

Fairbanks, Morse & Co.
Howe Scale Co.
Richardson Scale Co.
Yale & Towne Mfg. Co.

SCALES, WEIGH HOPPER

Atlas Car & Mfg. Co.
Bodinson Mfg. Co., Inc.
Columbus Conveyor Co.
Hevi & Patterson, Inc.
Holmes & Bros., Inc., Robert
Koehring Co.
Link-Belt Co.
Lippmann Engineering Works
McNally Pittsburg Mfg. Co.
Schaffer Poidometer Co.
Webster Mfg., Inc.

SCINTILLATION COUNTERS—See Geiger & Scintillation Counters

SCRAPERS, DRAGLINE, SURFACE & UNDERGROUND

Alloy Steel & Metals Co.
Elmco Corp.
Electric Steel Foundry Co.
Gardner-Denver Co.
Joy Mfg. Co.
Koehring Co.
Lake Shore Engineering Co.
Landis Steel Co.
Manitoba Steel Foundries, Ltd.
Page Engineering Co.
Rogers Iron Works Co.
Sauerman Bros., Inc.
Sorel Steel Foundries, Ltd.
Superior-Lidgerwood-Mundy Corp.
Vulcan Iron Works (Colo.)

SCRAPERS, SELFPROPELLED & WHEELED

Allis-Chalmers Mfg. Co., Tractor Div.
American Tractor Equipment Co.
Caterpillar Tractor Co.
Gar Wood Industries, Inc.
General Motors Corp., Euclid Div.
International Harvester Co.
LeTourneau-Westinghouse Co.
Wooldridge Mfg. Co.

SCRAPER HOISTS—See Hoists or Winches

SCRAPER PARTS & ATTACHMENTS, DRAGLINE

Alloy Steel & Metals Co.
American Brake Shoe Co.
Colorado Fuel & Iron Corp.
Electric Steel Foundry Co.
Joy Manufacturing Co.
Marion Power Shovel Co.
Page Engineering Co.
Sauerman Bros., Inc.
Sorel Steel Foundries
Vulcan Iron Works (Colo.)

SCREENS, CENTRIFUGAL

Bodinson Mfg. Co., Inc.
Flocker & Co., John
Hendrick Mfg. Co.
Hewitt-Robins, Inc.
McNally Pittsburg Mfg. Co.
Nordberg Mfg. Co.
Tyler Co., W. S.

SCREENS, ELECTRICALLY HEATED

Allis-Chalmers Mfg. Co.
Deister Concentrator Co.
Deister Machine Co.
Hewitt-Robins, Inc.
Link-Belt Co.
Productive Equipment Corp.
Simplicity Engrg. Co.
Tyler Co., W. S.
Universal Vibrating Screen Co.

SCREENS, GRAVITY

Colorado Fuel & Iron Corp.
Flocker & Co., John
Hendrick Mfg. Co.
Link-Belt Co.
Lippmann Engrg. Works
McNally Pittsburg Mfg. Co.
Remaly Mfg. Co.
Straub Mfg. Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Tyler Co., W. S.

SCREENS, LIP

Flocker & Co., John
Hendrick Mfg. Co.
Link-Belt Co.
McNally Pittsburg Mfg. Co.
Remaly Mfg. Co.

SCREENS, REVOLVING

Allis-Chalmers Mfg. Co.
Bodinson Mfg. Co.
Denver Equipment Co.
Flocker & Co., John
Hendrick Mfg. Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Laubenstein Mfg. Co.
Link-Belt Co.
Lippmann Engineering Works
Maddox Foundry & Machine Works
McLanahan & Stone Corp.
McNally Pittsburg Mfg. Co.
Meckum Engr. Co.
Pioneer Engineering Works
Remaly Mfg. Co.
Rogers Iron Works Co.
Smith Engineering Works
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.
Tyler Co., W. S.
Universal Dredge Mfg. Co.
Universal Engineering Co.
Universal Road Machinery Co.
Webb Corp.
Yuba Mfg. Co.

SCREENS, VIBRATING

Allis-Chalmers Mfg. Co.
Bodinson Mfg. Co.
Cambridge Wire Cloth Co.
Carrier Conveyor Corp.
Colorado Fuel & Iron Corp.
Daniels Company, Contractors, Inc.
Denver Equipment Co.
Deister Concentrator Co.
Deister Machine Co.
Diamond Mfg. Co.
Exolon Co.
Goodman Mfg. Co., Diamond Iron Works Div.
Flocker & Co., John
Georgia Iron Works Co.
Helmick Foundry-Machine Co.
Hendrick Mfg. Co.
Hewitt-Robins, Inc., Robins Conveyors Div.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Klockner-Humboldt-Deutz Ag.
Lecco Machinery & Engineering Co.
Link-Belt Co.
Lippmann Engineering Works
Machinery Center, Inc.
Maddox Foundry & Machine Works
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Overstrom & Sons
Pioneer Engineering Works, Inc.
Productive Equipment Corp.
Ridge Equipment Co.
Rogers Iron Works Co.
Savage Co., W. J.
Screen Equipment Co., Inc.
Simplicity Engineering Co.
Smith Engineering Works
Southwestern Engineering Co.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co.
Sturtevant Mill Co.
Sutton Steele & Steele, Inc.
Syntron Co.
Tyler Co., W. S.
Universal Engineering Co.

Universal Vibrating Co.
Webb Corp.
Williams Patent Crusher & Pulv. Co.

SCREEN CLOTH—see Cloth, Wire

SCREEN ECCENTRICS & VIBRATORS

Bodinson Mfg. Co., Inc.
Continental Gin Co., Industrial Div.
Hendrick Mfg. Co.
Hewitt-Robins, Inc.
Holmes & Bros., Inc., Robert
Link-Belt Co.
McNally Pittsburg Mfg. Co.
Syntron Co.
Tyler Co., W. S.

SCREEN HEATERS

Allis-Chalmers Mfg. Co.
Deister Concentrator Co.
Deister Machine Co.
Hannon & Sons, F. R.
Hewitt-Robins, Inc.
Lincoln Electric Co.
Link-Belt Co.
Tyler Co., W. S.
Universal Vibrating Screen Co.

SCREEN PLATE, SHEET

American Brake Shoe Co., Amsco Div.
Card Iron Works Co., C. S.
Chicago Perforating Co.
Flocker & Co., John
Harrington & King Perforating Co.
Hendrick Mfg. Co.
Hewitt-Robins, Inc.
Laubenstein Mfg. Co.
Lecco Mach. & Engineering Co.
Link-Belt Co.
National Malleable & Steel Castings Co.
Phillips Corp.
Remaly Mfg. Co.
Yuba Mfg. Co.

SCREEN, WIRE & BAR

American Brake Shoe Co.
Bixby-Zimmer Engineering Co.
Cleveland Wire Cloth & Mfg. Co.
Colorado Fuel & Iron Corp.
Hendrick Mfg. Co.
Hewitt-Robins, Inc.
Hoyt Wire Cloth Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Korb-Pettit Wire Fabrics & Iron Works
Lecco Mach. & Engineering Co.
Ludlow-Saylor Wire Cloth Co.
Newark Wire Cloth Co.
Overstrom & Sons
Phillips Corp.
Star Wire Screen & Iron Works
Stephens-Adamson Mfg. Co.
Tema, N. Y.
Tyler Co., W. S.
Wedge Bar Screen Corp.
Wedge-Wire Corp.

SCRUBBERS

Allis-Chalmers Mfg. Co.
Bodinson Manufacturing Co., Inc.
Denver Equipment Co.
Ducon Co.
Elmco Corp.
Iowa Mfg. Co.
Johnson-March Corp.
Landis Steel Co.
Link-Belt Co.
Lippmann Engrg. Wks.
Mine and Smelter Supply Co., Marcy Mill Div.
McLanahan & Stone Corp.
Mechanical Industries, Inc.
Pettibone Mulliken Corp.
Pioneer Engineering Works, Inc.
Rogers Iron Wks. Co.
Ruth Co.
Smith Engineering Works
Southwestern Engineering Co.
Stearns-Roger Mfg. Co.
Straub Mfg. Co.
Traylor Engineering & Mfg. Co.
Universal Engineering Co.
Universal Road Machinery Corp.
Yuba Mfg. Co.

SEPARATORS—See specific item below; also see Classifiers

SEPARATORS, AIR

Combustion Engineering, Inc.
Hardinge Co., Inc.
Johnson Corp.
Majac, Inc.
New Jersey Meter Co.
Sutton, Steele & Steele, Inc.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
U. S. Hoffman Corp., Air Appl. Div.
Wilkerson Valve, Inc.

SEPARATORS, ELECTROSTATIC

Carpco Manufacturing, Inc.
Engineers Syndicate, Ltd.
Koppers Co.
Ritter Products Corp.
Sutton, Steele & Steele, Inc.
Westinghouse Electric International Co.

SEPARATORS, HEAVY MEDIA—See Heavy Media Separators

SEPARATORS, MAGNETIC

Batson Electronics Corp., J. A.
Cutler-Hammer, Inc.
Dings Magnetic Separator Co.
Electric Controller & Mfg. Co.
Engineers Syndicate, Ltd.
Eriez Mfg. Co.
Exolon Co.
Frantz Co., S. G.
Homer Mfg. Co.
Jeffrey Mfg. Co.
Magnetic Engineering & Mfg. Co.
Stearns Magnetic, Inc.
Stearns-Roger Mfg. Co.
Sutton, Steele & Steele, Inc.
Thumes Mek. Vaerksted, A. S.

SEPARATORS, SPIRAL

Humphrey Investment Co., Engineering Div.

SHAFT SINKING CONTRACTORS

Allen & Garcia Co.
Dravo Corp.
Foley Bros., Inc.
Hoffman Bros. Drilling Co., Inc.
Johnson Co., R. G.
Longyear Co., E. J.
Minerals Engineering Co.
Mott Core Drilling Co.
Tinney Drilling Co.
Utah Construction Co.
Winston Bros. Company

SHEAVES—Also see Blocks & Sheaves and Pulleys

Allis-Chalmers Mfg. Co.
American Brake Shoe Co., American Manganese Steel Div.
American Hoist & Derrick Co.
American Pulley Co.
Bodinson Mfg. Co., Inc.
Boston Woven Hose & Rubber Co.
Brown-Fayro Co.
Card Iron Works Co., C. S.
Coeur d'Alene Hardware & Foundry Co.
Connellsville Mfg. & Mine Supply Co.
Continental Gin Co., Industrial Div.
Dodge Mfg. Corp.
Holmes & Bros., Inc., Robert
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Joy Mfg. Co.
Lake Shore Engineering Co.
Link-Belt Co.
Lovejoy Flexible Coupling Co.
Maddox Foundry & Machine Works
Madesco Tackle Block Co.
Meckum Engr. Co.
Medart Co.
Prescott Co.
Riblet Tramway Co.
Sanford-Day Iron Works, Inc.
Sauerman Bros., Inc.
Sorel Steel Foundries, Ltd.
Taylor-Wharton Iron & Steel Co.
Thompson-Starrett Co., Inc. Roberts & Schaefer Co.
Tool Steel Gear & Pinion Co.
U. S. Rubber Co., Mach. Gds. Div.
Vulcan Iron Works (Colo.)
Vulcan Iron Works (Pa.)
Washington Iron Works
Webster Mfg., Inc.
Worthington Corp.
Yuba Mfg. Co.

SHOVELS, POWER

American Hoist & Derrick Co.
American Steel Dredge Co., Inc.
Baldwin-Lima-Hamilton Corp.
Bay City Shovels, Inc.
Bucyrus-Erie Co.
Caterpillar Tractor Co.
Clark Equipment Co., Construction Machinery Div.
Dominion Engineering Co., Ltd.
Elmco Corp.
Gar Wood Industries, Inc.
Harnischfeger Corp.
Insley Mfg. Corp.
Koehring Co.
Link-Belt Speeder Corp.
Manitowoc Engineering Corp.
Marion Power Shovel Co.
Michigan Power Shovel Co.
Northwest Engineering Co.
Quick-Way Truck Shovel Co.
Schield Bantam Co.
Thew Shovel Co.
Unit Crane & Shovel Corp.
Webster Mfg., Inc.

SHOVEL DIPPERS, POWER—See Dippers

SHOVEL DIPPER TEETH

American Brake Shoe Co., American Manganese Steel Div.
Bucyrus-Erie Co.
Elmco Corp.
Electric Steel Foundry Co.
H & L Tooth Co.
Kensington Steel Co.
Maddox Foundry & Machine Works
Page Engineering Co.
Pettibone Mulliken Corp.
Sorel Steel Foundries, Ltd.
Taylor-Wharton Iron & Steel Co.
Thomas Foundries, Inc.

SIEVES, SHAKING

Allis-Chalmers Mfg. Co.
Braun Corp.
Gilson Screen Co.
Hendrick Mfg. Co.
Southwestern Engineering Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Tyler Co., W. S.
Universal Vibrating Screen Co.

SIEVES, TESTING

Braun Corp.
Denver Equipment Co.
Gilson Screen Co.
Hendrick Mfg. Co.
Southwestern Engineering Co.
Syntron Co.
Tyler Co., W. S.
Universal Vibrating Screen Co.

SINTERING MACHINES

Allis-Chalmers Mfg. Co.
Dominion Engineering Co., Ltd.
Dravo Corporation
Heyl & Patterson, Inc.
Mace Co.
Pollock Co., William B.
Sintering Machinery Corp., Dwight-Lloyd, Inc., Div.

SINTERING BARS, GRATES, & PALLETS

Cincinnati Mine Machinery Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
National Malleable & Steel Castings Co.
Sintering Machinery Corp.

SKIPS & CAGES

Card Iron Works Co., C. S.
Connellsville Mfg. & Mine Supply Co.
Coeur d'Alene Hardware & Foundry Co.
Denver Equipment Co.
Heyl & Patterson, Inc.
Holmes & Bros., Inc., Robert
Jeffrey Mfg. Co.
Jones Foundry & Machine Co., W. A.
Lake Shore Engineering Co.
Link-Belt Co.
Mayo Tunnel & Mine Equip. Co.
National Iron Co.
Nolan Co.
Nordberg Mfg. Co.
Ogden Iron Works Co.
Stearns-Roger Mfg. Co.
Superior-Lidgerwood-Mundy Corp.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Universal Dredge Mfg. Co.
Vulcan Iron Works (Pa.)
Wellman Engineering Co.

SPEED REDUCERS & INCREASERS—Also see Drives and Torque Converters

Allis-Chalmers Mfg. Co.
American Pulley Co.
Brad Foote Gear Works
Christian Engineers, J. D.
Cleveland Worm & Gear Co.
Continental Gin Co., Industrial Div.
Conveyor Co.
Denver Equipment Co.
Dodge Manufacturing Co.
Dominion Engineering Co., Ltd.
Elliott Co., Crocker-Wheeler Div.
Falk Corp.
Farrel-Birmingham Co.
Graybar Elec. Co., Inc.
Jones Foundry & Machine Co., W. A.
Link-Belt Co.
Master Mfg. Co.
Meckum Engr. Co.
Philadelphia Gear Works
Snow-Nabstedt Gear Corp.
Stephens-Adamson Mfg. Co.
Twin Disc Clutch Co.
U. S. Electrical Motors, Inc.
Western Gear Works
Westinghouse Electric Corp.

SPROCKETS, CHAIN

American Brake Shoe Co.
American Conveyor Co.
Bodinson Mfg. Co., Inc.
Chain Belt Co.
Christian Engineers, J. D.
Cincinnati Mine Machinery Co.
Continental Gin Co., Industrial Div.
Diamond Chain Co.
Universal Vibrating Co.
Heyl & Patterson, Inc.
Jeffrey Mfg. Co.
Link-Belt Co.
Maddox Foundry & Machine Works
McNally Pittsburg Mfg. Co.
Morse Chain Co.
Pettibone Mulliken Corp.
Taylor-Wharton Iron & Steel Co.
Tool Steel Gear & Pinion Co.
Webster Mfg., Inc.
Yuba Mfg. Co.

STEEL, ALLOY—PLATES, SHAPES, ETC.—Also see Drill Steel and Mine Supports, Metal

Allegheny Ludlum Steel Corp.
American Brake Shoe Co., American Manganese Steel Div.
American Steel Foundries, Inc.
Armco Steel Corp.
Atlas Steels, Ltd.
Barium Steel Corp.
Bethlehem Pacific Coast Steel Corp.
Bethlehem Steel Co.
Carpenter Steel Co.
Colorado Fuel & Iron Corp.
Crucible Steel Co. of America
Dominion Steel & Coal Corp., Ltd.
Duriron Co., Inc.
Firth Sterling, Inc.
Hoyland Steel Company, Inc.
Jones & Laughlin Steel Corp.
Midvale Co.
National Malleable & Steel Castings Co.
Republic Steel Corp.
Ryerson & Son, Inc., Joseph T.
Simonds Saw and Steel Co.
Sorel Steel Foundries, Ltd.
Timken Roller Bearing Co.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
Union Carbide & Carbon Corp., Electro Metallurgical Co. Div.
U. S. Steel Corp.
Vanadium-Alloys Steel Co.
Youngstown Sheet & Tube Co.

STEEL—PLATES, SHAPES, ETC.—Also see Drill Steel and Mine Supports, Metal

Armco Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Crucible Steel Co. of America
Dominion Steel & Coal Corp., Ltd.
Inland Steel Co.
Jones & Laughlin Steel Corp.
Lukens Steel Co.
National Iron Co.
Republic Steel Corp.
Ryerson & Son, Inc., Jos. T.
U. S. Steel Corp.
Wheeling Steel Corp.
Youngstown Sheet & Tube Co.

STEEL MINE SUPPORTS & CIRCULAR SETS—See Mine Supports, Metal

SURVEYING EQUIPMENT & SUPPLIES—also see Drafting Equipment & Supplies

Ainsworth & Sons, Inc., Wm.
American Paulin System
Bausch & Lomb Optical Co.
Berger & Sons, Inc., C. L.
Brunson Instrument Co., Inc.
Buff & Buff Mfg. Co.
Eugene Dietzgen Co.
Geo-Optic Co., Inc.
Gurley, W. & L. E.
Keuffel & Esser Co.
Kern Instruments, Inc.
Leupold & Stevens Instruments, Inc.
Longyear Co., E. J.
Lufkin Rule Co.
Rocky Mountain Instrument Co.
Sharp Instruments, Ltd.
Suverkrop Instruments
Warren-Knight Co.
White Co., David
Wild Heerbrugg Instruments, Inc.
Zeiss Aerotopograph

TANKS, METAL & GLASS LINED

Caldwell Co., W. E.
Denver Equipment Co.
Smith Co., A. O.
Wooldridge Mfg. Co.

TANKS, RUBBER LINED

American Hard Rubber Co.
Caldwell Co., W. E.
Denver Equipment Co.
Galigher Co.
Goodall Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Hauser-Stander Tank Co.
Linatex Corp. of America
Michigan Pipe Co.
Pioneer Rubber Mills
Quaker Pioneer Rubber Mills
Raybestos-Manhattan, Inc.
Thermoid Co.
U. S. Rubber Co., Mechanical Goods Div.

Wooldridge Mfg. Co.

TANKS, STEEL

ACF Industries, Inc.
American Locomotive Co.
Barium Steel Corp.
Baughman Mfg. Co.
Beall Pipe & Tank Corp.
Bethlehem Steel Co.
Black, Sivalls & Bryson, Inc.
Bodinson Mfg. Co., Inc.
Butler Mfg. Co.
Caldwell Co., W. E.
Chattanooga Boiler & Tank Co.
Chicago Bridge & Iron Co.
Columbian Steel Tank Co.
Denver Equipment Co.
General American Transportation Corp.
Graver Tank & Mfg. Co.
Linatex Corp. of America
Lippmann Engineering Works
Maddox Foundry & Machine Works
Mahon Co., R. C.
McNally Pittsburg Mfg. Co.
Michigan Pipe Co.
Pittsburgh-Des Moines Steel Co.
Posey Iron Works, Inc.
Ryerson & Son, Inc., J. T.
Smith Co., A. O.
Southwestern Engineering Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Treadwell Co., M. H.
Vulcan Iron Works (Pa.)
Webb Corp.
Wooldridge Mfg. Co.

TANKS, WOOD

Acme Tank Mfg. Co.
Arrow Tank Co.
Black, Sivalls & Bryson, Inc.
Caldwell Co., W. E.
Denver Equipment Co.
Federal Pipe & Tank Co.
M & M Woodworking Co.
Michigan Pipe Co.
Morse Bros. Machinery Co.
National Tank & Pipe Co.
Pacific Wood Tank Corp.
Santa Fe Tank & Tower Co.

TELEVISION, INDUSTRIAL

Curtiss-Wright Corp., Electronics Div.
Diamond Power Specialty Corp.

THERMOMETERS, INDICATING & RECORDING

Bailey Meter Co.
Braun Corp.
Bristol Co.
Davis Instrument Mfg. Co., Inc.
Foxboro Co.
General Electric Co., Apparatus Sales Div.
H-B Instrument Co.
Leeds & Northrup Co.
Republic Flow Meters Co.
Sarco Co., Inc.
Thwing-Albert Instrument Co., Tagliabue Instruments Div.
Weston Elec. Instrument Corp.

THICKENERS

Dagley Mfg. Co.
Daniels Company, Contractors, Inc.
Denver Equipment Co.
Dorr-Oliver, Inc.
Dow Chemical Co.
Gallagher Co.
Hardinge Co., Inc.
Heyl & Patterson, Inc.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Link-Belt Co.
Morse Bros. Machinery Co.
Peterson Filters & Engrg. Co.
Shriver & Co., Inc., T.
Western Machinery Co.

TIMBER FRAMERS

Denver Equipment Co.
Stearns-Roger Mfg. Co.

TIMBERING MACHINES

Baker-Raulang Co., Industrial Truck Div.
Goodman Mfg. Co.
Joy Mfg. Co.
Lee-Norse Co.
Stearns-Roger Mfg. Co.

TIMBER PRESERVATIVES

Allied Chemical & Dye Corp., Barrett Div.
American Lumber & Treating Co.
Baxter Co., J. H.
C-A Wood Preserver Co.
Cabot, Inc., Samuel
Carbolineum Wood Preserving Co.
Curtin-Howe Corp.
Darworth, Inc., Cuprinol Div.
Dow Chemical Co.
du Pont de Nemours & Co., E. I.
Koppers Co.
Oronite Chemical Co.
Osmose Wood Preserving Co. of America
Reilly Tar & Chemical Corp.
Republic Creosoting Co.
Sonneborn Sons, Inc.
Tennessee Products & Chemical Corp.
U. S. Steel Corp.

TIRES & TUBES

Armstrong Rubber Co.
Cities Service Oil Co.
Firestone Tire & Rubber Co.
Gates Rubber Company
General Tire & Rubber Co.
Goodrich Co., B. F.
Goodyear Tire & Rubber Co.
Seiberling Rubber Co.
U. S. Rubber Co., U. S. Royal Tire Div. & Mechanical Goods Div.

TOOLS, HAND

Ampco Metal, Inc.
Blackhawk Mfg. Co.
Simonds Saw & Steel Co.
Wood Shovel & Tool Co.

TORQUE CONVERTERS—Also see Drives

General Motors Corp., Allison Div.
National Supply Co.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
Twin Disc Clutch Co.
Western Gear Works

TRACK—See Rail & Track

TRACK CLEANING MACHINES

American Mine Door Co.

TRACK GAGE-RODS & LEVELS

Aldon Co.
Central Frog & Switch Co.
Nolan Co.
Oliver Iron & Steel Corp.
West Virginia Steel & Mfg. Co.

TRACK SWITCH THROWERS

American Brake Shoe Co.
American Mine Door Co.
Card Iron Works Co., C. S.
Central Frog & Switch Co.
Cheatham Electric Switching Device Co.
Nolan Co.
Pettibone Mulliken Corp.
U. S. Steel Corp.
West Virginia Steel & Mfg. Co.

TRACTORS, CRAWLER & WHEEL TYPE

Allis-Chalmers Mfg. Co., Tractor Div.
Austin Western Co.
Baker-Lull Corp.
Case Co., J. I.
Caterpillar Tractor Co.
Clark Equipment Co.
Diesel Energy Corp., Klockner-Humboldt-Deutz Ag.
Elmco Corp.
Hough Co., Frank G.
International Harvester Co.
Kersey Mfg. Co.
Lee-Norse Co.
LeTourneau-Westinghouse Corp.
Oliver Corp.
Sheppard Co., Inc., R. H.

TRACTOR ATTACHMENTS

Allis-Chalmers Mfg. Co., Tractor Div.
American Tractor Equipment Corp.
Austin Western Co.
Baker Manufacturing Co.
Caterpillar Tractor Co.
Clark Equipment Co.
Drott Mfg. Corp.
Easton Car & Construction Co.
Elmco Corp.
Electric Steel Foundry Co.
Gar Wood Industries, Inc.
Hendrickson Mfg. Co.
Hough Co., Frank G.
Hyster Co.
International Harvester Co.
Le Tourneau-Westinghouse Co.
Oliver Corp.
Trackson Co.
Tractomotive Corp.
Wooldridge Manufacturing Co.

TRAMP IRON DETECTORS

Dings Magnetic Separator Co.
Eriez Mfg. Co.
Femco Inc.
Homer Mfg. Co.
Industrial Physics & Electronics Co.
Magnetic Engineering & Mfg. Co.
Radio Corp. of America
Stearns Magnetic, Inc.

TRANSFORMERS

Allis-Chalmers Mfg. Co.
General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
Machinery Center, Inc.
Moloney Electric Co.
Pennsylvania Transformer Co.
Wagner Electric Corp.
Westinghouse Electric Corp.

TRANSITS, POCKET

Ainsworth & Sons, William
Suverkrop Instruments

TRANSMISSIONS, VARIABLE SPEED—Also see Drives

Allis-Chalmers Mfg. Co.
American Blower Corp.
Brad Foote Gear Works
Christian Engineers, J. D.
Dodge Mfg. Corp.
Dominion Engineering Co., Ltd.
Eaton Manufacturing Co., Dynamatic Div.
Falk Corp.
Fuller Mfg. Co.
Jones Foundry & Machine Co., W. A.
Link-Belt Co.
Lovejoy Flexible Coupling Co.
New York Air Brake Co.
Oliver Iron & Steel Corp.
Reeves Pulley Co.
Reliance Elec. & Eng. Co.
Rockwell Spring & Axle Co., Timken-Detroit Axle Div.
U. S. Electrical Motors, Inc.
Vickers, Inc.
Western Gear Works

TRAPS, AIR & STEAM

New Jersey Meter Co.
Nicholson & Co., W. H.
Sarco Co., Inc.
Wilkerson Valve, Inc.

TROLLEY EQUIPMENT

Anderson Mfg. Co., Albert & J. M.
Elreco Corp.
Goodrich Co., B. F.
Link-Belt Co.
McKiernan-Terry Corp.
Mining Machine Parts, Inc.
Ohio Brass Co.
Reading Crane & Hoist Corp.
Westinghouse Electric Corp.

TRUCKS & TRUCK TRACTORS

Chrysler Corp., Dodge Div.
Dart Truck Co.
Federal Motor Truck Co.
Ford Motor Co.
Fourwheel Drive Auto Co.
General Motors Corp., GMC Truck & Coach Div., Chevrolet Mfg. Div.
General Motors Corp., Euclid Div.
Hercules Steel Products Corp.
International Harvester Co.
Kenworth Motor Truck Corp.
Klockner-Humboldt-Deutz Ag.
Mack Truck, Inc.
Marmon-Harrington Co.
Oshkosh Motor Truck, Inc.
Prime Mover Co.
Walter Motor Truck Co.
White Motor Co., Autocar Div.

TRUCK (& TRACTOR) TRAILERS

Athey Products Corp.
Beall Pipe & Tank Corp.
C & D Mfg. Co.
Easton Car & Construction Co.
Fruehauf Trailer Co.
General Motors Corp., Euclid Div.
Gramm Trailer Corp.
Hendrickson Motor Truck Co.
Hercules Steel Prod. Corp.
La Crosse Trailer Corp.
McCabe-Powers Auto Body Co.
Rogers Bros. Corp.
Winter-Weiss Co.

TRUCK & TRAILER BODIES

Baughman Mfg. Co.
Easton Car & Construction Co.
Galion Allsteel Body Co.
Heil Co.
Hercules Steel Products Corp.
Hockensmith Corp.
LeTourneau-Westinghouse Co.
Marion Metal Products Co.
Maxon Construction Co.
Schonrock Equipment Mfg. Co.
Winter-Weiss Co.
Wooldridge Mfg. Co.

TUBING, METAL—Also See Pipe

Babcock & Wilcox Co.
Calumet & Hecla, Inc., Wolverine Tube Div.
Timken Roller Bearing Co.

TURBINES, STEAM & HYDRAULIC

Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Leffel & Co., James

ULTRAVIOLET LIGHTS

Braun Corp.
Engineers Syndicate, Ltd.
General Electric Co.
Menlo Research Laboratory
Sylvania Electric Products, Inc.
Ultra-Violet Products, Inc.
Westinghouse Electric Corp.

UNLOADERS

Barber-Greene Co.
McKiernan-Terry Corp.

USED EQUIPMENT—See E&MJ Searchlight Section, page 221

VALVES

ACF Industries, Inc.
Albert Pipe Supply Co.
Allen-Sherman-Hoff Pump Co.
American Chain & Cable Co., R-P & C Valve Div.
American Locomotive Co.
Barrett Haentjens & Co.
Bristol Co.
Coeur d'Alene Hardware & Foundry Co.
Commercial Shearing & Stamping Co.
Conrader Co., R.
Crane Co.
Darling Valve & Mfg. Co.
Dixon Valve & Coupling Co.
Dominion Engineering Co., Ltd.
Duriron Co., Inc.
Electric Steel Foundry Co.
Fairbanks Co.
Farris Engineering Corp.
Farris Flexible Valve Co.
Galland-Henning Mfg. Co.
General American Transp. Co.
Grinnell Co., Inc.
Hamer Valves, Inc.
Homestead Valve Mfg. Co.
Hose Accessories Co.
Jeffrey Mfg. Co.
Jenkins Bros.
Knox Mfg. Co.
LaBour Co.
Ledeen Mfg. Co.
Lunkenheimer Co.
McNally Pittsburg Mfg. Co.
Meckum Engr. Co.
Merco Nordstrom Valve Co.
Mine & Smelter Supply Co., Marcy Mill Div.
Nathan Manufacturing Corp.
New York Air Brake Co.
Nicholson & Co., W. H.
Ohio Brass Co.
Philadelphia Gear Works
Porter Co., Inc., H. K., Watson-Stillman Co. Div.
Powell Co., William
Rockwell Mfg. Co.
Sarco Co., Inc.
Schaible Co., D. T. Williams Valve Co. Div.
Vickers, Inc.
Walworth Co.
Weston Elec. Instrument Corp.
Wilkerson Valve, Inc.
Worthington Corp.
Yuba Mfg. Co.

VALVE OPERATING MECHANISMS—also see Controls

Bristol Co.
Conrader Co., R.
Jenkins Bros.
Ledeen Mfg. Co.
Philadelphia Gear Works
Sarco Co., Inc.

VENTILATION PIPE & TUBING

American Brattice Cloth Corp.
Bemis Bros. Bag Co.
Flexaust Co.
Flexible Tubing Corp.
Naylor Pipe Co.
Taylor Forge & Pipe Works

VIBRATORS

Cleveland Vibrator Co.
Jeffrey Mfg. Co.
Martin Engineering Co.
Meckum Engr. Co.
Syntron Co.
Tyler Co., W. S.

VOLTAGE REGULATORS

Allis-Chalmers Mfg. Co.
Braun Corp.
General Electric Co., Apparatus Sales Div.
Graybar Electric Co., Inc.
Westinghouse Electric Corp.
Weston Elec. Instrument Corp.

WATER CLARIFICATION & TREATMENT EQUIPMENT & SUPPLIES

Allied Chemical & Dye Corp., General Chemical Div.
Allis-Chalmers Mfg. Co.
American Sand-Banum Co., Inc.
Denver Equipment Co.
Dorr-Oliver, Inc.
Dow Chemical Co.
Elmco Corp.
Hardinge Co., Inc.
Heyl & Patterson, Inc.
Jeffrey Mfg. Co.
Link-Belt Co.
Permutit Co.
Peterson Filters & Engrg. Co.
Philadelphia Quartz Co.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co.
Water Neutralizing Co.

WEIGH HOPPERS—See Scales, Weigh Hopper

WELDING EQUIPMENT & SUPPLIES

Air Reduction Sales Co.
Anderson Mfg. Co., Albert & J. M.
American Brake Shoe Co., American Manganese Steel Div.
American Chain & Cable Co., Page Steel & Wire Div.
Continental Mineral Proc. Corp.
Eutectic Welding Alloys Corp.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
Guyan Machinery Co.
Harnischfeger Corp.
Hewitt-Robins, Inc.
Hobart Bros. Co.
Industrial Air Products Co.
Lincoln Electric Co.
Linde Air Products Co.
Metal & Thermit Corp.
Metallizing Equipment Co., Inc.
Morse Bros. Machinery Co.
National Cylinder Gas Co., Tube Turns Div.
Ohio Brass Co.
Phoenix Metal Products
Resisto-Loy Co.
Revere Copper & Brass, Inc.
Sight Feed Generator Co.
Smith Co., A. O.
Tweco Products Company
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
U. S. Steel Corp., American Steel & Wire Div.
Victor Equipment Co.
Wall Colmonoy Corp.
Westinghouse Electric Corp.

WELDING ELECTRODES—Also see Hardfacing

Air Reduction Co., Inc.
Alloy Rods Co.
American Brake Shoe Co., American Manganese Steel Div.
Ampco Metal, Inc.
Crucible Steel Co. of America
Eutectic Welding Alloys Corp.
General Electric Co., Apparatus Sales Div.
Harnischfeger Corp.
Hobart Bros. Co.
Lincoln Electric Co.
McKay Co.
Meckum Engrg. Co.
Metal & Thermit Corp.
Pure Carbon Co., Inc.
Sight Feed Generator Co.
Smith Co., A. O.
Stulz-Sickles Co.
Taylor-Wharton Iron & Steel Co.
Union Carbide & Carbon Corp., Haynes Stellite Co. Div.
Victor Equipment Co.
Westinghouse Electric Corp.

WHEELS—See Car (& Locomotive) Wheels

WINCHES—see specific item below also see Hoists

WINCHES, AIR & HYDRAULIC

Gardner-Denver Co.
Ledeen Mfg. Co.
Lidgerwood Industries, Inc.
Vickers, Inc.

WINCHES, DIESEL & GASOLINE

Lidgerwood Industries, Inc.

WINCHES, ELECTRIC

Christian Engineers, J. D.
Clyde Iron Works, Inc.
Harnischfeger Corp.
Holmes & Bros., Inc., Robert
Joy Mfg. Co.
Lidgerwood Industries, Inc.
Magnus, Inc., W. R.
Robbins & Myers, Inc.
Sanford-Day Iron Works, Inc.
Shepard Niles Crane & Hoist Corp.
Stephens-Adamson Mfg. Co.
Wellman Engrg. Co.
Yale & Towne Mfg. Co.
Yuba Mfg. Co.

WINCHES, HAND

Christian Engineers, J. D.
Indiana Foundry Co.
Link-Belt Co.
Lug-All Co.
Magnus, Inc., W. R.
Stephens-Adamson Mfg. Co.
Thompson-Starrett Co., Inc.
Robert & Schaefer Co.
Yale & Towne Mfg. Co.

WIRE CLOTH—see Cloth, Wire

WIRE ROPE

American Chain & Cable Co.
Bergen Wire Rope
Bethlehem Steel Co.
Broderick & Bascom Rope Co.
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
Colorado Fuel & Iron Corp., **Roebling's Sons Corp.**, John A.
Edwards Wire Rope Co.
Jones & Laughlin Steel Corp.
LeTourneau-Westinghouse Co.
Macwhyte Company
Paulsen-Webber Cordage Corp.
Porter Co., Inc., H. K., Leschen Wire Rope Div.
Rochester Ropes, Inc.
Sauerman Bros.
Sunbury Wire Rope Mfg. Co.
Union Wire Rope Corp.
United States Steel Corp., American Steel & Wire Div. Columbia-Geneva Steel Div.
Upson-Walton Co.
Wire Rope Corp. of America, Inc.

WIRE ROPE DRESSING—See Lubricants

WIRE ROPE FITTINGS

American Chain & Cable Co.
American Hoist & Derrick Co.
Colorado Fuel & Iron Corp., Roebling's Sons Corp., John A.
Hayes Steel Products, Ltd.
Interstate Drop Forge Co.
Jones & Laughlin Steel Corp.
Laughlin Co., Thomas
Macwhyte Company
Oliver Iron & Steel Corp.
Paulsen-Webber Cordage Corp.
Sauerman Bros.
Sunbury Wire Rope Mfg. Co.
U. S. Steel Corp., American Steel & Wire Div.
Upson-Walton Co.

WIRE ROPE SLINGS

American Chain & Cable Co.
Bergen Wire Rope
Broderick & Bascom Rope Co.
Colorado Fuel & Iron Corp., Roebling's Sons Corp., John A.
Jones & Laughlin Steel Corp.
Macwhyte Company
Paulsen-Webber Cordage Corp.
Sunbury Wire Rope Mfg. Co.
Union Wire Rope Corp.
Upson-Walton Co.
U. S. Steel Corp., American Steel & Wire Div.

WIRE SCREEN—see Screen, Wire & Bar

ZINC DUST

American Cyanamid Co., Mineral Dressing Div.
Baker Chemical Co., J. T.
Mechanical Industries, Inc.
New Jersey Zinc Co.

The classified advertising in **E&MJ's SEARCHLIGHT SECTION** on page 221 is an excellent guide to sources of **USED EQUIPMENT** and other special services.

PROFESSIONAL SERVICES, including **CONSULTANTS,** are advertised on page 218. The experts listed can solve many of your difficult problems.

SECTION 2: COMPANY ADDRESSES

A

A & A Mfg. Co., 2017 W. Clybourn St., Milwaukee 3, Wis.
Abart Gear & Machine Co., 4836 W. 16th St., Chicago 50, Ill.
A. B. Atlas Diesel Copco Eastern, 151 Linwood Ave., Paterson 2, N.J.
Abrams Aerial Survey Corp., 606 E. Shiawassee St., Lansing 1, Mich.
ACF Industries, Inc., 30 Church St., New York 7, N.Y.
Acker Drill Co., 725 W. Lackawanna Ave., Scranton 3, Pa.
Ackerman-Johnson Co., 625 Jackson Blvd., Chicago 6, Ill.
Acme Drilling Service, 832 Cleveland St., Oakland 6, Calif.
Acme Electric Heating Co., 1217 Washington St., Boston 18, Mass.
Acme Fishing Tool Co., Parkersburg, W. Va.
Acme Machinery Co., P.O. Box 1169 Williamson, W. Va.
Acme Road Machinery Co., E. Main St., Frankfort, N.Y.
Acme Tank Mfg. Corp., 5400 S. Soto St., Los Angeles 11, Calif.
Adalet Mfg. Co., 1448 E. 49th St., N.E. Cleveland, Ohio
Adam Electric Co., Frank, 3654 Windsor Pl., St. Louis 13, Mo.
Adams Co., J. D., 217 S. Belmont Ave., Indianapolis 6, Ind.
Adapti Co., 2996 E. 72nd St., Cleveland, Ohio.
Advance Car Mover Co., Inc., Box 536, 112 N. Outagamie St., Appleton, Wis.
Advance Electric & Relay Co., 2435 N. Naomi St., Burbank, Calif.
Aerodyne Atlantic Corp., 44 Wall St., New York 5, N.Y.
Aerofall Mills, Ltd., 129 Adelaide St. W., Toronto, Canada. ADV. p 175
Aeroquip Corp., 300 S. East Ave., Jackson, Mich.
Aero Service Corp., 210 E. Courtland St., Philadelphia 20, Pa. ADV. p 129
Aetna Ball & Roller Bearing Co., 4600 Schubert Ave., Chicago 39, Ill.
Ahlberg Bearing Co., 3025 W. 47th St., Chicago 32, Ill.
Ainsworth & Sons, Inc., Wm., 2151 Lawrence St., Denver 5, Colo. ADV. p 193
Air Reduction Co., Inc., Air Reduction Sales Co. Div., 60 E. 42nd St., N.Y., N.Y.
Ajax Flexible Coupling Co., Westfield, N.Y.
Ajax Metal Co., 46 Richmond St., Philadelphia, Pa.
Alan Wood Steel Co., Wood Road, Conshohocken, Pa.
Albany Car Wheel Co., Albany 1, N.Y.
Albany Felt Co., Albany 1, N.Y.
Albert Pipe Supply Co., Berry & North 13th Sts., Brooklyn, N.Y.
Aldon Company, The, 3338 Ravenswood Ave., Chicago 13, Ill.
Aldrich Pump Co., 1 Pine St., Allentown, Pa.
Alexander Bros., 406 N. 3rd St., Philadelphia 23, Pa.
Algonquin Coupling Co., 1700 N. Hancock St., Philadelphia, Pa.
Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.
Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill. ADV. p 261
Allen-Bradley Co., 1305 S. 1st St., Milwaukee 4, Wis.
Allen Cone & Machinery Corp., 120 Broadway, New York, N.Y.
Allen-Sherman-Hoff Pump Co., The, 259 E. Lancaster Ave., Wynnewood, Pa. ADV. 2nd Cover
Alliance Machine Co., Alliance, Ohio
Allied Chemical & Dye Corp., Baker & Adamson Co. Div., 40 Rector St., New York 6, N.Y. ADV. p 178
Allied Chemical & Dye Corp., Barrett Div., 40 Rector St., New York 6, N. Y. ADV. p 178
Allied Chemical & Dye Corp., General Chemical Div., 40 Rector St., New York 6, N.Y. ADV. p 178
Allied Chemical & Dye Corp., Solvay Process Div., 40 Rector St., N.Y. 6, N.Y. ADV. p 178
Allied Steel Products, Inc., 7835 Broadway, Cleveland 5, Ohio
Allied Steel & Tractor Products, Inc., 7835 Broadway, Cleveland 5, Ohio
Allis-Chalmers Mfg. Co., 969 S. 70th St., Milwaukee 1, Wisc. ADV opposite 98, 132, 133
Allis-Chalmers Mfg. Co., The Buda Co., 154 & Commercial Sts., Harvey, Ill.
Allis-Chalmers Mfg. Co., Gen. Machy. Div., Milwaukee 1, Wisc. ADV. opposite 98
Allis-Chalmers Mfg. Co., Tractor Div., Milwaukee 1, Wisc. ADV. p 132, 133
Allis Co., Louis, 427 E. Stewart St., Milwaukee 7, Wis.
Allison Steel Mfg. Co., South 19th Ave., Phoenix, Ariz.
Alloy Rods Co., Lincoln Highway West York, Pa.
Alloy Steel & Metals Co., 1862 E. 55th St., Los Angeles 11, Calif.
All-State Welding Alloys Co., Inc., 249-55 Ferris Ave., White Plains, N.Y.
All-Steel Equipment, Inc., 10 Kensington Ave., Aurora, Ill.
Alpha Corp., Greenwich, Conn.
Alphaduct Wire & Cable Co., Ford Ave., Milltown, N.J.
Aluminum Co. of America, 1501 Alcoa Bldg., 425 6th Ave., Pittsburgh 22, Pa.
Alvey-Ferguson Co., 72 Disney St., Cincinnati 9, Ohio
American Abrasive Metals Co., 460 Coit St., Irvington 11, N.J.
American Air Filter Co. Inc., 215 Central Ave., Louisville 8, Ky. ADV. p 191
American Asbestos Textile Corp., Stanbridge & Sterigere Sts., Norristown, Pa.
American Blower Corp., Detroit 32, Mich.
American Brake Shoe Co., American Manganese Steel Div., 389 E. 14th St., Chicago Heights, Ill.
American Brake Shoe Co., Electro Alloys Div., Elyria, Ohio
American Brake Shoe Co., National Bearing Div., 4930 Manchester Ave., St. Louis 10, Mo.
American Brake Shoe Co., Ramapo Ajax Div., 332 S. Michigan Ave., Chicago 4, Ill.
American Brake Shoe Co., Southern Wheel Div., 230 Park Ave., New York 17, N.Y.
American Brass Co., Waterbury 20, Conn.
American Brattice Cloth Corp., Warsaw, Ind. ADV. p 172
American Car & Foundry Co., 30 Church St., New York 7, N.Y.
American Cast Iron Pipe Co., Birmingham 2, Ala.
American Chain & Cable, Wilkes Barre, Pa. Mr. Emerson Todd, Sls. Mgr.
American Chain & Cable Co., American Cable Div., Bridgeport 2, Conn.
American Chain & Cable Co., American Chain Div., York, Pa.
American Chain & Cable Co., Ford Chain Block Div., 2nd & Diamond Sts., York, Pa.
American Chain & Cable Co., Hazard Wire Rope Div., Bridgeport 2, Conn.
American Chain & Cable Co., Page Steel & Wire Div., Monessen, Pa.
American Chain & Cable Co., Reading Steel Casting Div., Reading, Pa.
American Chain & Cable Co., R-P&C Valve Div., Tulpehocken Ave., Reading, Pa.
American Chain & Cable Co., Wright Hoist Div., Princess & Charles Sts., York, Pa.
American Coldset Corp., 87-89 Court St., Paterson, N.J.
American Conveyor Co., 1115 West Adams St., Chicago 7, Ill.
American Crucible Products Co., 1307 Oberlin Ave., Lorain, Ohio
American Cyanamid Co., Explosives Dept., 30 Rockefeller Pl., New York 20, N.Y. ADV. p 136, 137
American Cyanamid Co., Mineral Dressing Dept., 30 Rockefeller Pl., N.Y. 20, N.Y. ADV. p 136, 137
American Diamond Drill Co., 1975 S. 2nd West, Salt Lake City, Utah
American Electric Switch Corp., Minerva, O.
American Emery Wheel Works, Richmond Square, Providence 1, R.I.
American Engineering Co., 2413 Aramingo, Philadelphia, Pa.
American Flexible Coupling Co., 1801 Pittsburgh Ave., Erie, Pa.
American Forge Co., Alvarado & Niles Road, Niles, California.
American Gear & Mfg. Co., 5900 Ogden Ave., Chicago 50, Ill.
American Hard Rubber Co., 93 Worth St., New York 13, N.Y.
American Gum Products Co., 500 Fifth Ave., New York, N.Y.
American Hoist & Derrick Co., 63 S. Robert St., St. Paul, Minn.
American Hoist & Derrick Co., Crosby Products Div., 63 S. Robert St., St. Paul 1, Minn.
American Hoist & Derrick Co., Laughlin Co. Div., 143 Fore St., Portland 6, Me.
American Hydraulics, Inc., Sheboygan, Wis.
American Instrument Co., Inc., Silver Spring, Md.
American Locomotive Co., 143 Erie Blvd. Bldg., Schenectady, N.Y.
American Lumber & Treating Co., 332 S. Michigan Ave., Chicago 4, Ill.
American Machine & Foundry Co., Leland Electric Co. Div., 1501 Webster, Dayton 1, Ohio
American Machine & Metals, Inc., De Bothezat Fan Div., East Moline, Ill.
American Machine & Metals, Inc., U. S. Gauge Div., Sellersville, Pa.
American-Marietta Co., 43 E. Ohio St., Chicago 11, Ill.
American-Marsh Pumps, Inc., 60 Capital Ave., Battle Creek, Mich.
American Metal Moulding Co., 146 Coit St., Irvington 11, N.J.
American Meter Co., 1513 Race St., Philadelphia 2, Pa.
American Mine Door Co., Dueber Ave., Canton 6, Ohio. ADV. p 143
American Mine Supply Co., 404 Frick Bldg., Pittsburgh 19, Pennsylvania
American Oil Co., American Bldg., Baltimore, Md.
American Optical Co., 14 Mechanic St., Southbridge, Mass.
American Paulin System, 1524 S. Flower St., Los Angeles 15, Calif.
American Potash & Chemical Corp., 3030 W. 6th St., Los Angeles 54, Calif.
American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.
American Pulverizer Co., 1275 Macklind Ave., St. Louis 10, Mo.
American Rectifier Co., 95 Lafayette St., New York, N.Y.
American Rubber Mfg. Co., 1145 Park Ave., Oakland 8, Calif.
American Sand-Banum Co., Inc., 9 Rockefeller Plaza, New York, N. Y.
American Smelting & Refining Co., 120 Broadway, New York 5, N.Y. ADV. p 194
American Smelting & Refining Co., Federated Metals Div., 120 Broadway, New York 5, N. Y.
American Spectographic Laboratories, 557 Minna St., San Francisco, Calif.
American Steel Dredge Co., Inc., 2511 Taylor St., Ft. Wayne, Ind.
American Steel Foundries, 400 N. Michigan, Chicago 11, Ill.
American Tractor Equip. Corp., 9131 San Leandro Blvd., Oakland 3, Calif.
American Ventilating Hose Co., 100 Park Ave., New York, N. Y.
American Water Softener Co., Lehigh Ave. & 4th St., Philadelphia 33, Pa.
American Well Works, 180 N. Broadway, Aurora, Ill.
American Wheelabrator & Equip. Corp., 555 S. Brykit St., Mishawaka, Ind.
Ames Iron Works, 25 E. 2nd St., Oswego, N. Y.
Ammann Photogrametric Engineers, Inc., Jack Broadway at 10th, San Antonio, Tex.
Ampco Metal, Inc., 1723 So. 38th St., Milwaukee 46, Wis.
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N.Y. ADV. p 115
Analytical Measurements, Inc., 585 Main St., Chatham, N.J. ADV. p 206
Anderson Mfg. Co., Albert & J. M., 289—A St., Boston 10, Mass.
Ansonia Wire & Cable Co., 63 Main St., Ansonia, Conn.
Ansul Chemical Co., Marinette, Wis.
Anthony Co., Streator, Ill.
Antsell Instrument Co., 6515 Anstell St., Detroit 13, Mich.

Antwerp Industrial Diamond Co., 535 Fifth Ave., New York 17, N. Y.
Apache Powder Co., Benson, Ariz.
Apex Bolt Products Co., 1303 Carroll Ave., Chicago 7, Ill.
Appleton Electric Co., 1744 Wellington Ave., Chicago 13, Ill.
Arcos Corp., 1500 S. 50th St., Phila. 43, Pa.
Arizona Assay Office, 815 N. 1st St., Phoenix, Arizona.
Arizona Testing Laboratories, 817 W. Madison St., Phoenix, Ariz.
Arkell & Smiths, Canajoharie, N. Y.
Armco Drainage & Metal Products, Inc., 2133 Curtis St., Middletown, Ohio.
Armco Steel Corp., 703 Curtis St., Middletown, Ohio. ADV. p 214
Armco Steel Corp., Sheffield Steel Div., Sheffield Station, Kansas City 25, Mo. ADV. p 214
Armor Electric Mfg. Co., 1020 Holland St., Erie, Pa.
Armour & Co., Chemical Div., 1355 W. 31st St., Chicago 9, Ill. ADV. p 211
Armstrong-Bray & Co., 5364 Northwest Hwy., Chicago 30, Ill.
Armstrong Rubber Co., West Haven, Conn.
Arnold & Weigel, Inc., Woodville, Ohio.
Aros Electric, Inc., 16 E. 71st St., New York 21, N.Y. ADV. p. 195
Arro Expansion Bolt Co., N. Boone Ave., Marion, Ohio.
Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.
Arrowhead Steel Buildings, Inc., 367 Garfield Ave., Duluth 6, Minn. ADV. p 189
Arrow Tank Co., 16 Barnett St., Buffalo 15, N. Y.
Asbestos Fibre Spinning Co., North Wales, Pa.
Asbestos Mfg. Co., Huntington, Ind.
Ashland Oil & Refining Co., 1409 Winchester Ave., Ashland, Ky.
Ashland Oil & Refining Co., Valvoline Oil Co. Div., Freedom, Pa.
Assembly Products, Inc., Main & Bell Sts., Chagrin Falls, Ohio.
Associated Metals & Minerals Corp., 75 West St., New York 6, N. Y.
Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.
Athey Products Co., 5631 W. 65th St., Chicago 38, Ill.
Atkins & Co., E. C., 402 S. Illinois St., Indianapolis 9, Ind.
Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Atlantic Tank Corp., 1207 Tonnelle Ave., North Bergen, N. J.
Atlas Car & Mfg. Co., 1100 Ivanhoe Rd., Cleveland 10, Ohio. ADV. p 259
Atlas Chain & Mfg. Co., Castor & Kensington Aves., Philadelphia 24, Pa.
Atlas Conveyor Co., Clintonville, Wis.
Atlas Diesel, A. B., Copco Eastern, 151 Linwood Ave., Paterson 2, N. J.
Atlas Foundry Co., 533 Lyons Ave., Irvington 11, N. J.
Atlas Imperial Diesel Engine Co., 1000-19th Ave., Oakland 6, Calif.
Atlas Powder Co., Wilmington 99, Del.
Atlas Steel Casting Co., 1963 Elmwood Ave., Buffalo 7, N. Y.
Atlas Steels, Ltd., Welland, Ontario, Canada.
Atomic Research Corp., T-380 Peterson Field, Colorado Springs, Colo.
Austin Co., M. B., 116 S. Desplaines St., Chicago 6, Ill.
Austin Powder Co., Rockefeller Bldg., Cleveland, Ohio
Austin Power Co., Cleveland 13, Ohio
Austin-Western Co., Aurora, Ill.
Auth Electric Co., 34-20 45th St., Long Island City, N.Y.
Auto-Lite Battery Corp., Toledo 1, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Switch Co., 391 Lakeside Ave., Orange, N.J.

B

Babcock & Wilcox Co., The, 161 E. 42nd St., New York 17, N.Y. ADV. p 150, 151
Bacharach-Strauss, First Ave. & Ferry St., Pittsburgh 22, Pa.
Bacon-Greene & Milroy, 205 Church St., New Haven 10, Conn.
Badger Malleable & Mfg. Co., South Milwaukee, Wis.
Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio
Baker Castor Oil Co., 118 Broadway, New York 5, N. Y.
Baker Chemical Co., J. T., Phillipsburg, N.J.
Baker-Lull Corp., 314 W. 90th St., Minneapolis 20, Minn.
Baker Mfg. Co., 514 Stanford Ave., Springfield, Ill.
Baker-Raulang Co., Industrial Truck Div., 1250 W. 80th St., Cleveland 2, Ohio
Baker, V. G., Fairbanks, Alaska
Balderson Mfg. Co., Wamego, Kansas
Baldor Electric Co., 4351-67 Duncan Ave., St. Louis 10, Mo.
Baldwin-Lima-Hamilton Corp., Paschall Post Office, Philadelphia 42, Pa. ADV. p 134
Baldwin-Lima-Hamilton Corp., Baldwin Locomotive Works, Standard Steel Works Div., Burnham, Pa. ADV. p 134
Baldwin-Lima-Hamilton Corp., Construction Equipment Div., Box L, Lima, Ohio. ADV. p 134
Barber-Colman Co., Wheelco Instrument Div.-B-I-F Industries, Inc., 1300 Rock St., Rockford, Ill.
Barber-Greene Co., 400 N. Highland Ave., Aurora, Ill.
Barco Mfg. Co., 1801 Winnemac Ave., Chicago 40, Ill.
Barium Steel Corp., 25 Broad St., New York, N.Y.
Barkelew Electric Mfg. Co., Middletown, O.
Barnes Mfg. Co., 651 N. Main St., Mansfield, Ohio
Barrett, Haentjens & Co., Hazleton, Pa. ADV. p 140, 141
Bart-Messing Corp., 222 Main St., Belleville 9, N.J.
Bartlett & Snow Co., C. O., 6300 Harvard Ave., Cleveland 5, Ohio
Bates Co., Walter, 1707 Rowell Ave., Joliet, Ill.
Bath Iron Works Corp., Pennsylvania Crusher Div., Room 1712, West Chester, Pa. ADV. p 160
J. A. Batson Electronics Corp., Waterloo, Nebr.
Battery Co., K. W., 3555 Howard St., Skokie, Ill.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N.Y.
Baxter Co., J. H., 200 Bush St., San Francisco 4, Calif.
Bay City Shovels, Inc., Bay City, Mich.
Bayonne Bolt Corp., 32 W. 2nd St., Bayonne, N.J.
Bay State Abrasive Products Co., 12 Union St., Westboro, Mass.
Beach & Company, 131 E. 8th St., Leadville, Colo.
Beall Pipe & Tank Corp., 12005 N. Burgard St., Portland 3, Ore.
Bearings, Inc., 3634 Euclid Ave., Cleveland 15, Ohio
Beaumont Birch Co., 1505 Race St., Philadelphia 2, Pa.
Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, California
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif.
Beckman Instruments Inc., Berkeley Div., 2200 Wright Ave., Richmond, Calif.
Bedford Foundry & Machine Co., Bedford, Ind.
Beebe Bros., 2724—6th Ave. So., Seattle 4, Wash.
Beech Aircraft Corp., Wichita 1, Kans.
Be-Ge Mfg. Co., 885 N. Monterey St., Gilroy, Calif.
Behr, Manning Corp., 1933 Sidford St., Troy, N.Y.
Bell Aircraft Corp., Niagara Falls, N.Y.
Bellevue Industrial Furnace Co., 2971 Bellevue Ave., Detroit 7, Mich.
Belmont Packing & Rubber Co., Butler & Sepviva Sts., Philadelphia 37, Pa.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N.Y.
Bemis Bros. Bag Co., 408 E. Pine St., St. Louis 2, Mo.
Bendelari, F. N., Joplin, Mo.
Benjamin Electric Mfg. Co., Des Plaines, Ill.
Bennetts Chemical Laboratory, Inc., 901 S. 9th St., Tacoma 3, Wash.
Bennington Scale Mfg. Co., 4325 N. 3rd St., Philadelphia, Pa.
Bergen Wire Rope, Lodi, New Jersey
Berger & Sons, Inc., C. L., 31 St. James St., Boston 16, Mass.
Berk & Co., Inc., F. W., Coast Chemical Division, 55 New Montgomery St., San Francisco 5, Calif.
Beryllium Corp. of Pa., Temple St., Reading, Pa.
Bete Fog Nozzle, Inc., 85 Pierce St., Greenfield, Mass.
Bethlehem Foundry & Machine Co., W. 2nd St., Bethlehem, Pa.
Bethlehem Steel Co., Bethlehem, Pa.
Bethlehem Pacific Coast Steel Corp., 20th & Illinois Sts., San Francisco, Calif.
Bico, Inc., 3116 Valhalla Drive, Burbank, Calif.
B-I-F Industries, Inc., Wheelco Instrument Div., Barber-Colman Co., 1300 Rock St., Rockford, Ill.
Bigelow Co., 72 River St., New Haven, Conn.
Bigelow-Liptak Corp., 2550 W. Grand Blvd., Detroit 8, Mich.
Bin-Dicator Co., 13946 R2 Kercheval St., Detroit 15, Mich. ADV. p 192
Bingham Pump Co., 2800 N.W. Front St., Portland, Ore.
Binks Mfg. Co., 3114 Carroll Ave., Chicago 12, Ill.
Bird Machine Co., South Walpole, Mass.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Birkle Pulley & Machine Co., 456 N. Union Ave., Chicago 10, Ill.
Bixby-Zimmer Engineering Co., 961 Abingdon St., Galesburg, Ill. ADV. p 164
Black & Deason, 160 South West Temple St., Salt Lake City 1, Utah
Black & Decker Mfg. Co., The, 600 East Pennsylvania Ave., Towson 4, Md.
Black Diamond Spad Co., 24 Tapoan Rd., Richmond 26, Va.,
Blackhawk Mfg. Co., 5325 W. Rogers St., Milwaukee 1, Wis.
Black Mfg. Co., 1416 W. Baltimore St., Baltimore, Md.
Black, Sivalls & Bryson, Inc., 720 Delaware, Kansas City 6, Mo.
Blaw-Knox Co., Blaw-Knox Div., Farmers Bank Bldg., Pittsburgh, Pa.
Blaw-Knox Co., Buflovak Equipment Div., 1629 Fillmore Ave., Buffalo 11, N.Y.
Blaw-Knox Co., Power Piping Div., 829 Beaver Ave., Pittsburgh, Pa.
Blount Co., J. G., 21 Woodland St., Everett 49, Mass.
Blue "M" Electric Co., 138th & Chatham St., Blue Island, Ill.
Bodinson Mfg. Co., 2401 Bayshore Blvd., San Francisco 24, Calif.
Bohn Aluminum & Brass Corp., Michigan Smelting & Refining Div., 7885 Jos. Campau Ave., Detroit 26, Mich.
Bolinders Co., 33 Rector St., New York, N.Y.
Bond Foundry & Machine Co., Manheim, Pa.
Bonded Scale & Machine Co., 69 Kingston, Columbus, Ohio
Bonnot Co., Canton, Ohio
Booth Co., Inc., The, 333 West 14 South St., Salt Lake City 4, Utah
Booth Engineers, 146 So. West Temple St., Salt Lake City 1, Utah
Borden Metal Products Co., Elizabeth, N.J.
Borg Warner Corp., Long Mfg. Div., 12501 Dequindre St., Detroit 12, Mich.
Borne Scrymser Co., 632 S. Front St., Elizabeth, N.J.
Boston & Lockport Block Co., 100 Condor St., Boston, Mass.
Boston Gear Works, Quincy 71, Mass.
Boston Metals Co., The Baldt Anchor Chain & Forge Div., P.O. Box 350, Chester, Pa.
Boston Woven Hose & Rubber Co., P.O. Box 1071, Boston 1, Mass.
Bowdill Co., The, Boylan Ave. S.E., Canton, Ohio
Bowen Products Corp., 4647-4th Ave., Ecorse 25, Mich.
Bower Roller Bearing Co., 5040 Hart Ave., Detroit 14, Mich.
Bowers Battery & Spark Plug Co., Box 1262, Reading, Pa.
Bowie Switch Co., 815 Tennessee St., San Francisco, Calif.
Boyles Bros. Drilling Co., 1321 South Main St., Salt Lake City 15, Utah
Boyles Bros. Drilling Co., Ltd. 1275-1291 Parker St., Vancouver 6, Canada
Brabender Corp., Rochelle Park, N.J.
Brad Foote Gear Works, 1309 South Cicero Ave., Cicero, Ill.
Bradley Pulverizer Co., 123 So. 3rd St., Allentown, Pa.

Brammer Co., 684 Broadway, New York 12, N.Y.
Brandeis, Goldschmidt & Co. Inc., 165 Broadway, N.Y. 6, N.Y.
Brass Foundry Co., 713 S. Adams St., Peoria 2, Ill.
Braun Corp., 2260 E. 15th St., Los Angeles 21, Calif.
Breeze Corp., 41 S. 6th St., Newark 7, N. J.
Bridgeport Brass Co., 30 Grand St., Bridgeport, Conn.
Bridgeport Chain & Mfg. Co., 962 Crescent Ave., Bridgeport 1, Conn.
Bridgeport Switch Co., 209 Center St., Bridgeport, Conn.
Briggs & Stratton Corp., 2711 North St., Milwaukee 1, Wis.
Bright Light Reflector Co., Fairfield & State, Bridgeport 5, Conn.
Bright Star Battery Co., Crooks & Getty Aves., Clifton, N. J.
Bristol Co., Waterbury 20, Conn.
Broderick & Bascom Rope Co., 4203 North Union Blvd., St. Louis 15, Mo.
Brooks Lumber Co., Box 153, Bellingham, Wash.
Brooks Oil Co., The, 934 Ridge Ave., Pittsburgh 12, Pa.
Brookville Locomotive Works, Steele Blvd., Brookville, Pa.
Bros Boiler & Mfg. Co., Wm., 1057—10th Ave. S.E., Minneapolis 14, Minn.
Brown-Brockmeyer Co., 1000 S. Smithville Rd., Dayton 1, Ohio
Brown & Co., D. P., 516 Howard St., Detroit 26, Mich.
Brown Engineering Co., 123 N. 3rd St., Reading, Pa.
Browning Crane & Shovel Co., 16226 Waterloo Rd. N.E., Cleveland 10, Ohio
Browning Mfg. Co., Maysville, Ky.
Bruce-Macbeth Engine Co., 2111 Center St. N.W., Cleveland 13, Ohio
Bruning Co. Inc., Charles, 4702 Montrose Ave., Chicago 41, Ill.
Brunner & Lay Inc., 9300 West King St., Franklin Park, Ill.
Brunner & Lay, Rock-Bit Corp., 2516 E. Cumberland St., Philadelphia 25, Pa.
Brunson Instrument Co., Inc., 1405 Walnut St., Kansas City 6, Mo.
Bryant Electric Co., 1421 State St., Bridgeport 2, Conn.
Buck Inc., Leonard J., 1 Newark Ave., Jersey City 2, N.J.
Buckeye Machine Co., O'Connor Ave., Lima, Ohio
Bucyrus-Erie Co., South Milwaukee, Wis. ADV. p 114
Bucil Engineering Co., 70 Pine St., New York 5, N.Y. ADV. p 153
Buff & Buff Mfg. Co., Jamaica Plain Boston, Mass.
Buffalo Forge Co., 490 Broadway, Buffalo 5, N.Y.
Buffalo Gasoline Motor Co., 1280 Niagara St., Buffalo 13, N.Y.
Buffalo Hammer Mill Corp., 1238 McKinley Pkwy., Buffalo 18, N.Y.
Buffalo Scale Co., Inc., 46 Letchworth St., Buffalo 13, N.Y.
Buffalo Wire Works Co., 308 Terrace St., Buffalo 2, N.Y.
Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I.
Bulkley Dunton Processes, Inc., 295 Madison Ave., New York 17, N.Y.
Bullard Co., E. D., 275-8th St., San Francisco 3, Calif.
Bull Dog Electric Products Co., Detroit 32, Mich.
Bunting Brass & Bronze Co., 715 Spencer St., Toledo 9, Ohio
Burgess Battery Co., Freeport, Ill.
Burndy Engineering Co., Inc., Post Rd, Norwalk, Conn.
Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.
Burton Equipment Co., Inc., 4810 Firestone Blvd., South Gate, Calif.
Bury Compressor Co., 1722 Cascade St., Erie, Pa.
Butler Bin Co., 993 Blackstone Ave., Waukesha, Wis.
Butler Mfg. Co., 7400 East 13th St., Kansas City 26, Mo.
Byers Co., A. M., Clark Bldg., Pittsburgh 22, Pa.
Byers Manufacturing Co., The, Lock Box 390, S. Sycamore St., Ravenna, Ohio
By-Products Recoveries, Inc., 90 West St., New York 6, N.Y.
Byron Jackson Co., P.O. Box 2017 Terminal Annex, Los Angeles 54, Calif.

C

C & D Batteries, Inc., Conshohocken, Pa.
C & D Manufacturing Co., Perkins, Calif.
Cabot, Inc., Samuel, Oliver Bldg, Boston 9, Mass.
Cadillac Malleable Iron Co., Cadillac, Mich.
Cadman Mfg. Co., A. W., 2816 Smallman St., Pittsburgh, Pa.
Calcium Chloride Institute, 909 Ring Bldg., Washington 6, D.C.
Caldwell Co., W. E., 2540 Brook St., Louisville 8, Ky.
Calebaugh Self Lubricating Carbon Co., 4637-39 Mulberry St., Phila. 24, Pa.
California Conduit & Cable Co., 2204 Orange St., Alhambra, Calif.
California Testing Laboratories, Inc., 1429 Santa Fe Ave., Los Angeles, Calif.
California Texas Oil Co., Ltd., 380 Madison Ave., New York, N.Y.
Calumet & Hecla Inc., Calumet Div., Calumet, Mich.
Calumet & Hecla, Inc., Wolverine Tube Div., 1850 Guardian Bldg., Detroit 26, Mich.
Cambridge Instrument Co., 3069 Grand Central Terminal, New York 17, N.Y.
Cambridge Wire Cloth Co., 152 Linkwood Rd., Cambridge, Md.
Cameron Iron Works, P.O. Box 1212, Houston, Texas.
Campbell Co., E. K., Manchester Ave., & 18th St., Kansas City 3, Mo.
Canada Wire & Cable Co., Ltd., P. S. "R", Toronto 17, Ontario, Canada
Canadian Industries, Ltd., Montreal, Canada
Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.
Cantol Wax Co., 211 N. Washington St., Bloomington, Ind.
Canton Malleable Iron Co., 2500—13th St. N.E., Canton 5, Ohio
Carbolineum Wood Preserving Co., 526 W. Highland Ave., Milwaukee 3 Wis.,
Carbon Engineering Corp., Slinger, Wis.
Carbone Corp., 400 Myrtle Ave., Boonton, N.J.
Carborundum Co., Box 337, Niagara Falls, N.Y.
The Carborundum Co., Refractories Div., Perth Amboy, N.J.
Card Iron Works Co., C. S., 2501 West 16th Ave., Denver 4, Colo. ADV. p 164
Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.
Carey Mfg. Co., Philip, Lockland, Cincinnati 15, Ohio
Cargille Laboratories, Inc., R. P., 117 Liberty St., New York 6, N.Y.
Carhart Refractories Co., 16th & Lee Sts., Louisville 10, Ky.
Carlile & Associates, J. C., 425 Cooper Bldg. Denver 2, Colo.
Carlon Products Corp., 10225 Meech Ave., Cleveland, Ohio
Carlyle Rubber Co., 64 Park Place, New York 7, N.Y. ADV. p 222
Carpco Manufacturing, Inc., Jacksonville 6, Fla.
Carpenter Steel Co., 115 W. Bern St., Reading, Pa.
Carrier Corp., 300 S. Geddes St., Syracuse 1, N. Y.
Carrier Conveyor Corp., 2144 Frankford Ave., Louisville, Ky. ADV. p 179
Carroll Chain Co., 200 Bruck St., Columbus, Ohio
Carter Co., Ralph B., 192 Atlantic St., Hackensack, N.J.
Carver Pump Co., Muscatine, Iowa
Case Co., J. I., Racine, Wisc.
Cash Co., A. W., 550 N. 18th St., Decatur, Ill.
Castle Hill Corp., Hartzell Propeller Fan Co. Div., P.O. Box 909, Piqua, Ohio
Catalytic Construction Co., 1528 Walnut St., Philadelphia 2, Pa. ADV. p 225
Catawissa Valve & Fittings Co., 500 Mill St., Catawissa, Pa.
Caterpillar Tractor Co., Peoria 8, Ill. ADV. p 262
C-A Wood Preserver Co., 6625 Delmar Blvd., St. Louis 5, Mo.
Cement Gun Co., Allentown, Pa.
Central Foundry Co., 386—4th Ave., New York, N.Y.
Central Frog & Switch Co., Watson Rd., Cincinnati 8, Ohio
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.
Central Mine Supply Co., Mt. Vernon, Ill.
Central Scientific Co., 1700 Irving Park Rd, Chicago 13, Ill.
Centric Clutch Co., Route 35 Woodbridge, N.J.
Centrifugal & Mechanical Industries, Inc., 146 President St., St. Louis 18, Mo.
Century Electric Co., 1806 Pine St., St. Louis 3, Mo.
Century Geophysical Corp., Interurban Bldg., Dallas, Texas
Ceramic Machinery Co., Midwest Locomotive Works Div., 406 First National Bank Bldg., Hamilton, Ohio
Cesco Mfg. Co., 123 E. 7th Ave., Homestead, Pa.
Chain Belt Co., 4679 West Greenfield Ave., Milwaukee 1, Wisc.
Chain Belt Co., Baldwin-Duckworth Div., 349 Plainfield St., Springfield 2, Mass.
Chain Belt Co., Shafer Bearing Div., P.O. Box 57, Downers Grove, Illinois
Channon Corp., J. H., 1447-55 W. Hubbard St., Chicago 22, Ill.
Chapman & Wood, 536 Jefferson St. N.E., Albuquerque, New Mex.
Charlton Laboratories, 2340 S. W. Jefferson St., Portland 7, Ore.
Charter Gas Engine Works, Sterling, Ill.
Chase Bag Co., 309 W. Jackson Blvd., Chicago 6, Ill.
Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Conn.
Chase-Shawmut Co., 390 Merrimac St., Newburyport, Mass.
Chatillon & Sons, John, 85 Cliff St., New York 38, N.Y.
Chattanooga Boiler & Tank Co., 1036 E. Main St., Chattanooga 1, Tenn.
Cheatham Electric Switching Device Co., 4780 Crittenden Dr., Louisville 9, Ky.
Chelsea Fan & Blower Co., Inc., 639 South Ave., Plainfield, N.J.
Chemical Construction Corp., 488 Madison Ave., New York 22, N. Y.
Chester Cable Corp., 521 Fifth Ave Chester, N.Y.
Chicago Belting Co., 113 N. Green St., Chicago 7, Ill.
Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 4, Ill.
Chicago Expansion Bolt Co., 1338 W. Concord Pl., Chicago 22, Ill.
Chicago Eye Shield Co., 2304 Warren Blvd., Chicago 12, Ill.
Chicago Gear Mfg. Co., 2833 W. Fulton St., Chicago 12, Ill.
Chicago Perforating Co., 2445—24th Pl., Chicago 5, Ill.
Chicago Pneumatic Tool Co., 6 E. 44th St., New York 17, N.Y.
Chicago Pulley & Shafting Co., 23 N. Desplaines St., Chicago 6, Ill.
Chicago Rawhide Mfg. Co., 1279 Elston Ave., Chicago, Ill.
Chicago Wheel & Mfg. Co., 1101 W. Monroe St., Chicago 7, Ill.
Chiksan Company, 330 North Pomona Ave., Brea, California
Chisholm-Moore Hoist Corp., 5045 Fremont Ave., Tonawanda, N.Y.
Christensen Diamond Products Co., 1937 S. Second West, Salt Lake City, Utah
Christiana Machine Co., Christiana, Pa.
Christian Engineers, J. D., 480 Potrero Ave., San Francisco 10, Calif. ADV. p 194
Chrysler Corp., Dodge Truck Div., 21500 Mound Rd., Detroit 11, Mich.
Chrysler Industrial Engine Div., Wyandotte, Mich.
Church Expansion Bolt Co., Isaac, 1 Fourth St., East Norwalk, Conn.
Ciba Co., 631 Greenwich St., New York 14, N.Y.
Cincinnati Electrical Tool Co., 2684 Madison Rd., Cincinnati 9, Ohio
Cincinnati Gasket & Packing Co., 1506 Gem St., Cincinnati, Ohio
Cincinnati Mine Machinery Co., 2980 Spring Grove Ave., Cincinnati 25, Ohio
Cincinnati Rubber Mfg. Co., Franklin Ave. & Norwood St., Cincinnati 12, Ohio
Cincinnati Steel Castings Co., Spring Grove, Alabama & Bates Aves., Cincinnati 25, Ohio
Circle F Mfg. Co., 720 Monmouth St., Trenton 4, N.J.
Cities Service Oil Companies, 54 Wall St., New York 5, N.Y.

Clapp Instrument Co., Webster, Mass.
Clarage Fan Co., 619 Porter St., Kalamazoo 16, Mich.
Clark Bros. Co., Olean, N.Y.
Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio
Clark Electronic Corp., Box 165, Palm Springs, Calif.
Clark Equipment Co., Construction Machinery Div., 331 Miller St., Benton Harbor, Mich. ADV. p 131
Clarkson Co., The, 564 Market St., San Francisco 4, Calif. ADV. p 224
Clarkson Mfg. Co., Nashville, Ill.
Cleveland Chain & Mfg. Co., 545 Henry St., Cleveland 5, Ohio
Cleveland Crane & Engrg. Co., 1036 E. 283rd St., Wickliffe, Ohio
Cleveland Electric Motor Co., 5213 Chester Ave., Cleveland 3, Ohio
Cleveland Quarries Co., Sterling Grinding Wheel Div., Tiffin, Ohio
Cleveland Switchboard Co., 2925 E. 79th St., Cleveland, Ohio
Cleveland Vibrator Co., 2828 Clinton Ave., Cleveland 13, Ohio
Cleveland Wire Cloth & Mfg. Co., 3573 E. 78th St., Cleveland 5, Ohio
Cleveland Worm & Gear Co., The, 3249 E. 80th St., Cleveland 4, Ohio. ADV. p 193
Clifton Conduit Co., (see Hatheway & Co.)
Climax Engine & Pump Mfg. Co., Clinton, Iowa
Climax Molybdenum Co., 500 Fifth Ave., New York 36, N.Y.
Cline Truck Co., 1116 Campbell St., Kansas City, Mo.
Cling-Surface Co., 1032 Niagara St., Buffalo 13, N.Y.
Clipper Belt Lacer Co., 974 Front St., N.W., Grand Rapids 2, Mich.
Clow & Sons, James B., 201-99 N. Talman Ave., Chicago 12, Ill.
Clyde Iron Works, Inc., 29th Ave. West & Michigan St., Duluth, Minn.
Coast Mfg. & Supply Co., Box 71, Livermore, Calif.
Coast Metals, Inc., P.O. Box 7, Little Ferry, N.J.
Coates Steel Products Co., Greenville, Ill.
Cochrane Corp., 3100 N. 17th St., Philadelphia 32, Pa.
Coeur d'Alene Hardware & Foundry Co., Wallace, Idaho
Coffing Hoist Co., 800 Walter St., Danville, Ill.
Coleman Instruments, Inc., 318 Madison St., Maywood, Ill.
Collyer Insulated Wire Co., 249 Roosevelt Ave., Pawtucket, R.I. ADV. p 202
Colorado Assaying Co., 2013 Welton St., Denver 1, Colo.
Colorado Core Drilling Co., 800 Pearl St., Boulder, Colo.
Colorado Fuel & Iron Corp., P.O. Box 1920, Denver 1, Colo.
Colorado Fuel & Iron Corp., Claymont Steel Div., Claymont, Md.
Colorado Fuel & Iron Corp., John A. Roebling's Sons Corp., 640 S. Broad St., Trenton 2, N.J.
Colorado Fuel & Iron Corp., Wickwire-Spencer Steel Div., 575 Madison Ave., New York 18, N.Y.
Colorado Iron Works Co., 1624—17th St., Denver 2, Colo. ADV. p 112, 113
Columbia Electric Mfg. Co., 4519 Hamilton Ave., N.E., Cleveland 14, Ohio
Columbia Steel Casting Co., Inc., 933 N. W. Johnson St., Portland 9, Ore.
Columbian Steel Tank Co., 1509 West 12th St., Kansas City 1, Mo.
Columbus Conveyor Co., 869 W. Goodale Blvd., Columbus 8, Ohio.
Columbus Forge & Iron Co., 544 W. First Ave., Columbus 8, Ohio.
Combustion Engineering, Inc., 200 Madison Ave., New York 16, N. Y.
Combustion Engineering — Superheater Inc., Raymond Pulverizer Div., 1323 N. Branch St., Chicago 22, Ill.
Commercial Shearing & Stamping Co., 1775 Lorain Ave., Youngstown, Ohio.
Commercial Solvent Corp., 260 Madison Ave., New York 16, N.Y.
Commercial Steel Casting Co., Marion, O.
Commercial Testing & Engrg. Co., 228 N. LaSalle St., Chicago, Ill.
Compton, Inc., P. O. Box 1946, Clarksburg, W. Va.
Conco Engineering Works, Mendota, Ill.
Concordia Electric Co., 1521 Saw Mill Run Blvd., Pittsburgh 10, Pa.
Condenser Service & Engineering Co., 150 Observer Highway, Hoboken, N. J.
Conduit Fittings Corp, 6400 W. 66th St., Chicago, Ill.
Cone-Drive Gears, 7171 E. McNichols Rd., Detroit 12, Mich.
Conley Frog & Switch Co., Bodley Ave., Memphis 9, Tenn.
Connecticut Tel. & Elec. Div., Great American Industries, Inc., 70 Britannia St., Meriden, Conn.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Conrader Co., R., 1209 French St., Erie, Pa.
Consolidated Diamond Drill Corp., Ltd., 33 Melinda St., Toronto, Ontario, Canada.
Consolidated Distributors, Inc., Box 237, Selma, Calif.
Consolidated Engineering Corp, N. Sierra Madre Villa & Foothill Blvd., Pasadena 8, Calif.
Consolidated Iron-Steel Mfg. Co., 1290 E. 53rd St., Cleveland 14, Ohio.
Consolidated Packaging Machinery Corp., 1400 West Ave., Buffalo 13, N. Y.
Construction Machinery Co., P. O. Box 120, Waterloo, Iowa.
Continental Battery Mfg. Corp., 1914 S. Pearl St., Dallas, Tex.
Continental-Diamond Fibre Co., Newark 44, Del.
Continental Electric Co., 325 Ferry St., Newark 5, N. J.
Continental Foundry & Machine Co., 220 Grant St., Pittsburgh 19, Pa.
Continental Gin Co., Industrial Div., P. O. Box 2614, Birmingham 2, Ala.
Continental Mfg. Co., Box 983, Kilgorf, Texas.
Continental Mineral Processing Corp., First National Bank Bldg., Cincinnati 2, Ohio. ADV. p 190
Continental Motors Corp., Muskegon, Mich.
Continental Oil Co., Sterling Bldg., Houston, Texas.
Continental Ore Corp., 500 5th Ave., New York, N. Y.
Continental Pipe Mfg. Co., Woolworth Bldg., New York, N. Y.
Continental Rubber Works, 1932 Liberty Blvd., Erie, Pa.
Control Corp., 718 Central Ave., Minneapolis 14, Minn.
Convair, Inc., 714 Brookline Blvd., Box 9671, Pittsburgh 26, Pa.
Conveyor Belt Service, Inc., Virginia, Minn.
Conveyor Co., The, 3260 E. Slauson Ave., Los Angeles 58, Calif.
Conveyor Systems, Inc., 325 S. California Ave., Chicago, Ill.
Conway Clutch Co., 2745 Colerain Ave., Cincinnati 25, Ohio.
Cook's Sons, Inc., Adam, 5 Stiles St., Linden, N. J.
Cooper-Bessemer Corp., Mt. Vernon, Ohio.
Cooper Split Roller Bearing Co., 2021 Milford Drive, Pittsburgh 34, Pa.
Coors Porcelain Co., 600—9th St., Golden, Colo.
Coover Railroad Track Brace Co., The P. O. Box 254, Dayton 1, Ohio.
Copco Eastern, 151 Linwood Ave., Paterson 2, N. J.
Copco Pacific, Ltd., 930 Brittan Ave., San Carlos, Calif.
Copperweld Steel Co., 9th St. & Allegheny Ave., Glassport, Pa.
Coppus Engineering Corp., 344 Park Ave., Worcester 2, Mass.
Coral Designs, 12-16 Astoria Blvd., Long Island City 2, N. Y.
Corhart Refractories Co., 1600 W. Lee St. So., Louisville 10, Ky.
Corning Glass Works, Corning, N. Y.
Cosmic Counters, 112 Cornell Ave., Swarthmore, Pa.
Cotta Transmission Co., 2300—11th St., Rockford, Ill.
Cover, H. S., 3905 S. Michigan St., South Bend 14, Ind.
Cox & Stevens Aircraft Corp., Glen Cove Rd., Mineola, Long Island, N. Y.
Cox & Stevens Electronic Scales, 630 Fifth Ave., New York 20, N. Y.
Craig Carroll Co., 1704 S.E. 22nd Ave., (Box 2208), Portland 15, Ore.
Cramp Brass & Iron Foundries Co., Chester Park, Philadelphia, Pa.
Crane Co., 836 S. Michigan Ave., Chicago 5, Ill.
Crane Puller Co., Waltham 54, Mass.
Crescent Belt Fastener Co., 480 Lexington Ave., New York 17, N. Y.
Crescent Insulated Wire & Cable Co., Olden & Taylor Aves, Trenton 5, N. J.
Crescent Tool Co., York & Western, Cincinnati, Ohio.
Crichton Co., 1006 U. S. National Bank Bldg., Johnstown, Pa.
The Joyce Cridland Co., 2027 East First St., Dayton 3, Ohio.
Critchett & Ferguson, 105 S. Santa Fe St., El Paso, Tex.
Crosby Steam Gage & Valve Co., 43 Kendrick St., Wrentham Mass.
Cross Engineering Co., 178 Dundaff St., Carbondale, Pa.
Crouse Hinds Co., Wolf & Seventh North Sts., Syracuse 1, N. Y.
Crowell Mfg. Co., Franklin Ave. & Clifton Place, Brooklyn 5, N. Y.
Crucible Steel Co. of America, 405 Lexington Ave., New York, N. Y.
Crucible Steel Co. of America, Oliver Bldg., Pittsburgh, Pa.
Cullen-Friestedt Co., 1300 S. Kilbourn Ave., Chicago 23, Ill.
Cullman Wheel Co., 1344 W. Altgeld St., Chicago 14, Ill.
Cummins Engine Co., Columbus, Ind.
Curtin-Howe Corp., 405 Lexington Ave., New York, N. Y.
Curtis Lighting, Inc., 6135 W. 65th St., Chicago 38, Ill.
Curtis Mfg. Co., 1905 Kienlen Ave., St. Louis 20, Mo.
Curtis Mfg. Co., Curtis Pneumatic Machinery Div., 1905 Kienlen Ave., St. Louis 20, Mo.
Curtiss-Wright Corp., Electronics Div., Carlstadt, N. J.
Custom Assay Office & Laboratory, 105 So. Santa Fe, El Paso, Tex.
Cutler-Hammer, Inc., 553 N. 12th St., Milwaukee 1, Wis.
Cyclotherm Corp., 90 Broad St., New York 4, N. Y.

D

Dagley Mfg. Co., 1217 E. 6th St., Joplin, Mo.
Dake Engine Co., Grand Haven, Mich.
D-A Lubricant Co., 1311 W. 29th St., Indianapolis, Ind.
Daniels Co., Contractors, Inc., 26 North 5th St., Indiana, Pa.
Daniels, Inc., C. R., 4900 Wetheredsville Road, Baltimore 16, Md.
Darling Valve & Mfg. Co., Foot of Walnut St., Williamsport, Pa.
Dart Mfg. Co., E. M., 134 Thurbers Ave., Providence 5, R. I.
Dart Truck Co., 2621 Oak St., Kansas City 8, Mo. ADV. p 154
Darworth, Inc., Cuprinol Div., Simsbury, Conn.
Davenport Besler Corp., 2305 Rockingham Rd., Davenport, Iowa.
Davey Compressor Co., Kent, Ohio.
Davidson Co., M. T., 7 Dey St., New York 7, N. Y.
Davis Co., Nelson L., 343 S. Dearborn St., Chicago 4, Ill.
Davis Foundry & Machine Works, Old Furnace Road, Rome, Ga.
Davis Instrument Mfg. Co., Inc., 513 E. 36th St., Baltimore 18, Md.
Day-O-Lite Equipment Co., 53 Clifford St., Providence, R. I.
Dayton Malleable Iron Co., 1307 W. 3rd St., Dayton 1, Ohio.
Dayton Rubber Co., Woodside Bldg., Greenville, S. C.
Dean Bros. Pumps, Inc., 323 W. 10th St., Indianapolis 7, Ind.
Dean Hill Pump Co., 4000 E. 16th St., Indianapolis 7, Ind.
Dearborn Motors Corp., Birmingham, Mich.
Deason & Nichols, 160 South West Temple St., Salt Lake City 1, Utah.
Deemer Steel Casting Co., New Castle, Del.
Diester Concentrator Co., The, 901 Glasgow Ave., Fort Wayne 1, Ind.
Deister Machine Co., 1933 E. Wayne St., Fort Wayne 4, Ind.

De Laval Steam Turbine Co., 855 Nottingham Way, Trenton 2, N. J.
Delta-Star Electric Co., 2400 Block-Fulton St., Chicago 12, Ill.
Deltron Electric Products, Inc., Ebensburg, Pa.
Deming Co., 42 Broadway, Salem, Ohio.
Dempster Bros., Inc., Springdale Ave. at Southern R. R., Knoxville 17, Tenn.
Denver Equipment Co., P. O. Box 5268, Denver 17, Colo. ADV. p 120
Denver Fire Clay Co., 2301 Blake St., P. O. Box 5510, Denver 17, Colo.
Despatch Oven Co., 619—8th St., S. E., Minneapolis 14, Minn.
Detectron Co., 5637 Cahuenga Blvd., North Hollywood, Calif.
Detroit Belt Lacer Co., 3945-51 A St., Detroit 16, Mich.
Detroit Hoist & Machine Co., 8224 Morrow St., Detroit 11, Mich.
DeWalt, Inc., Fountain Ave., Lancaster, Pa.
Dewey & Almy Chemical Co., 62 Whittemore Ave., Cambridge, Mass.
Diamond Chain Co., 452 Kentucky Ave., Indianapolis 7, Ind.
Diamond Drill & Carbon Co., 63 Park Row, New York 7, N. Y.
Diamond Drill Contracting Co., S. 18 Stone St., Spokane 15, Wash.
Diamond Iron Works Co., 1728 N. 2nd St., Minneapolis, Minn.
Diamond Mfg. Co., W. 8th St., Wyoming, Pa.
Diamond Power Specialty Corp., Lancaster, Ohio.
Diamond Products, Inc., 336 Prospect Ave., Elyria, Ohio.
Dick Co., R. & J., Sade St., Passaic, N. J.
Dicke Tool Co., 1201 Warren Ave., Downers Grove, Ill.
Dickinson Laboratories, 1300 W. Main St., El Paso, Texas.
Diehl Mfg. Co., 1199 Finderne Ave., Somerville, N. J.
Dietert Co., Harry W., 9330 Roselawn Ave., Detroit 4, Mich.
Dietzgen Co., Eugene, 218 E. 23rd St., New York 10, N. Y.
Differential Steel Car Co., Findlay, Ohio. ADV. p 182
Dings Magnetic Separator Co., 4780 W. Electric Ave., Milwaukee 14, Wis. ADV. p 205
Disston & Sons, Inc., Henry, Unruh & Milnor Sts., Philadelphia 35, Pa.
Dixon Crucible Co., Joseph, Monmouth & Wayne Sts., Jersey City 3, N. J.
Dixon Valve & Coupling Co., Phila. 22, Pa.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Dodge Mfg. Corp., South Union St., Mishawaka, Ind. ADV. p 144
Dolph Co., John C., New Road, Monmouth Junction, N. J.
Dominion Engineering Co., Ltd., First Ave., Lachine, P. Q., Canada
Dominion Steel & Coal Corp., Ltd., Canada Cement Bldg., Montreal, Quebec, Canada
Dooley Bros., 1201 S. Washington St., Peoria, Ill.
Dorr-Oliver Inc., Barry Place, Stamford, Conn.
Dorsey Trailers, Elba, Alabama.
Dow Chemical Co., The, Hopkins Bldg., Midland, Michigan.
Dow Corning Corp., Midland, Mich.
Dracco Corp., 4072 E. 116th St., Cleveland 5, Ohio.
Dravo Corp., Neville Island, Pittsburgh 25, Pa. ADV. p 181
Dresser Equipment Co., Kobe, Inc. Div., Huntington Park, Calif.
Dresser Industries, Inc., Dresser Mfg. Div., Bradford, Pa.
Dresser Industries, Inc., Roots-Connersville Blower Div., 900 W. Mount St., Connersville, Ind.
Dresser Operations, Inc., Clark Bros. Co. Div., P. O. Box 560, Olean, N. Y.
Dresser-Stacey Co., Stacey Bros. Div., 5535 N. Vine St., Cincinnati 16, Ohio.
Drilling Accessory & Mfg. Co., Inc., 2006 S. Industrial, Dallas, Texas. ADV. p 165
Drinkwater, Inc., Spring & Madison Sts., Waukegan, Ill.
Drott Mfg. Corp., 3841 W. Wisconsin Ave., Milwaukee 8, Wis.
Drullard Co., Howard, 1026 Folsom St., San Francisco 3, Calif.
Ducon Co., The, 157 E. 2nd St., Mineola, Long Island, New York.
Duff-Norton Mfg. Co., 2709 Preble Ave., Pittsburgh 30, Pa.
Dumore Co., 1300 - 17th St., Racine, Wis.
duPont deNemours & Co., E. I., duPont Bldg., Wilmington 98, Del.
duPont deNemours & Co., E. I., Explosives Dept., Wilmington, Del.
duPont deNemours & Co., E. I., Fabrics & Finishes Dept., Wilmington, Del.
duPont deNemours & Co., E. I., Grasselli Chemicals Dept., duPont Bldg., Wilmington, Del.
Duquesne Mine Supply Co., Pittsburgh 9, Pa.
Durakool, Inc., 1010 N. Main St., Elkhart, Ind.
Duraloy Co., Scottdale, Pa.
Duria-Werk Karl Kempf, Neuss/RH, Germany
Duriron Co., Inc., The, Dayton 1, Ohio. ADV. p 117
Durkee-Atwood Co., 215 N. E. 7th St., Minneapolis 13, Minn.
Dustex Corp., Box 2520, 1760 Walden Ave., Buffalo 25, N. Y.

E

Eagle Iron Works, P. O. Box 934, Des Moines 4, Iowa. ADV. p 186
The Eagle-Pitcher Co., American Bldg., Cincinnati 2, Ohio.
Earle Gear & Machine Co., 4723 Stenton Ave., Philadelphia 44, Pa.
Eastern Constructors, Inc., Poland, Ohio.
Eastern Electro-Casting Co., Ltd., 15 St. Jos. St., Lachine, Quebec, Canada.
Eastern Tube & Tool Co., 594 Johnson Ave., Brooklyn 6, N. Y.
Eastman Mfg. Co., 12th St., Manitowoc, Wis.
Easton Car & Construction Co., Easton, Pa. ADV. p 171
Eaton Mfg. Co., Dynamatic Div., 3307 - 14th Ave., Kenosha, Wisconsin.
Eberbach Corp., 200 E. Liberty St., Ann Arbor, Mich.
Eberhardt Denver Co., 1408 W. Colfax Ave., Denver 4, Colo.
Economy Fuse & Mfg. Co., Greenview Ave. at Diversey Pkwy., Chicago, Ill.
Edge Moor Iron Works, Inc., Edge Moor, Del.
Edison, Inc., Thomas A., Edison Storage Battery Div., Lakeside Ave., West Orange, N. J.
Edward Valves, Inc., 1200 W. 145th St., East Chicago, Ind.
Edwards & Co., H. D., 175 E. Larned St., Detroit, Mich.
Edwards Co., Inc., Norwalk, Conn.
Edwards Mfg. Co., 630 Eggleston Ave., Cincinnati 2, Ohio.
Edwards Wire Rope, P. O. Box 513, San Francisco, Calif.
Ehret Magnesia Mfg. Co., Valley Forge, Pa.
Eimco Corp., 634 South Fourth West St., Box 300, Salt Lake City 10, Utah. ADV. opposite p 162
Eisenhauer Laboratories, 322 S. San Pedro St., Los Angeles 13, Calif.
Eisler Engineering Co., 740 S. 13th St., Newark 3, N. J.
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.
Electrical Engineering & Mfg. Corp., Jefferson Blvd. at Farmdale, Los Angeles, 16, Calif.
Electrical Engineers Equipment Co., 25th St. & Division Ave., Melrose Park, Ill.
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Electrical Fittings Corp., 30-45 Starr Ave., New York, N. Y.
Electrical Mfg. Co., P. O. Box 30, Logan, W. Va.
Electric Arc, Inc., 158 Jelliff Ave., Newark, 8, N. J.
Electric Boat Co., Electro Dynamic Div., Avenue A & North St., Bayonne, N. J.
Electric Controller & Mfg. Co., 2701 E. 79th St., Cleveland 4, Ohio.
Electric Machinery Mfg. Co., 800 Central Ave., Minneapolis 13, Minn.
Electric Materials Co., North East, Pa.
Electric Products Co., 1725 Clarkstone Rd., Cleveland 12, Ohio.
Electric Service Mfg. Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland 10, Ore.
Electric Storage Battery Co., Exide Industrial Div., 42 So. 15th St., Phila 2, Pa. ADV. p 122
Electrokemisk, A. S., 101 Park Ave., NYC.
Electro Lift, Inc., 30 Church St., New York 7, N. Y.
Electroline Co., 4121 S. La Salle St., Chicago, Ill.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
Electronics Products Co., 5330 E. Olympic Blvd., Los Angeles 22, Calif.
Electro-Nite Carbon Co., 1133 E. Columbia Ave., Philadelphia 25, Pa.
Electro Products Laboratories, 4501 North Ravenswood Ave., Chicago, Ill.
Electro Refractories & Abrasives Corp., Willett Rd., Buffalo 19, N. Y.
Elkhart Brass Mfg. Co., 1301 W. Beardsley Ave., Elkhart, Ind.
Ellernan Co., The, 1210 Continental Bank Bldg., Salt Lake City 1, Utah
Ellicott Machine Corp., 1657 Bush St., Baltimore 30, Md.
Elliott Co., 900 N. Fourth Ave., Jeannette, Pa.
Elliott Co., Crocker-Wheeler Div., Ampere 5, N. J.
Elliott Co., Ridgway Div., Ridgway, Pa.
Elliot Co., B. K., 128 Sixth St., Pittsburgh.
El Paso Testing Laboratories, El Paso, Tex.
Elreco Corp., 2900 Cormany Ave., Cincinnati, Ohio.
El-Tronics, Inc., 2647 N. Howard St., Philadelphia 33, Pa.
Emerson Electric Mfg. Co., 8100 Florissant Ave., St. Louis 21, Mo.
Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio.
Empire Steel Castings, Inc., Reading, Pa.
Endicott Forging & Mfg. Co., 1901 North St., Endicott, N. Y.
Englehard, Inc., Charles, 850 Passaic Ave., East Newark, N. J.
Engineering Laboratories, Inc., 624 E. 4th St., Tulsa 3, Okla.
Engineers Syndicate, Ltd., 5011 Hollywood Blvd., Hollywood, Calif.
Enley Products, Inc., 1236 Broadway, Brooklyn 21, N. Y.
Ensign-Bickford Co., Simsbury, Conn. ADV. p 4
Ensign Electric & Mfg. Co., 914 Adams Ave., Huntington 4, W. Va. ADV. p 190
Enterprise Wheel & Car Corp., Bristol, Va.
Equipment Engineers, Inc., 41 Sutter St., San Francisco 4, Calif. ADV. p 102
Equitable Paper Bag Co., 45-50 Van Dam St., Long Island City 1, N. Y.
Equitable Powder Mfg. Co., East Alton, Ill.
Erico Products, Inc., 2070 E. 61st Pl., Cleveland 3, Ohio.
Erie City Iron Works, 1422 East Ave., Erie, Pa.
Erie Pump & Engine Works, 145 Glenwood Ave., Medina, N. Y.
Erie Steel Construction Co., Erie, Pa.
Eriez Mfg. Co., 202 Magnet Drive, Erie, Pa.
Essex Brass Corp., 2000 Franklin St., Detroit 7, Mich.
Essex Wire Corp., Paranite Wire & Cable Div., 1601 Wall St., Fort Wayne 6, Ind.
Esso Standard Oil Co., 15 W. 51st St., New York 19, N. Y.
Esterline-Angus Co., Indianapolis 6, Ind.
Euclid Crane & Hoist Co., 1365 Chardon Rd., Cleveland 17, Ohio.
Euclid Electric & Mfg. Co., 50 Edwards St., Madison, Ohio.
Euclid Road Machinery Co., 1361 Chardon Rd., Cleveland 17, Ohio.
Eutectic Welding Alloys Corp., 40-40 172 St., Flushing 58, N. Y.
Everlasting Valve Co., 49 Fisk St., Jersey City 5, N. Y.
Exolon Co., The, East Niagara St., Tonawanda, N. Y.

F

F. A. B. Mfg. Co., 1249—67th St., Oakland 8, Calif.
Fafnir Bearing Co., 37 Booth St., New Britain, Conn.
Failing Supply Co., Enid, Okla.
Fairbanks Co., The, 393 Lafayette St., NYC.
Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill.
Fairchild Aerial Surveys, Inc., 224 E. 11th St., Los Angeles, Calif.
Fairfield Engrg. Co., Marion, Ohio.
Fairmont Machinery Co., Fairmont, W. Va.
Falk Corp., 3049 W. Canal St., Milwaukee 8, Wisc. ADV. p 158

Farmers Engineering & Mfg. Co., 549 Brushton Ave., Pittsburgh 21, Pa.
Farquhar Co., A. B., 225 Duke St., York, Pa.
Farrel-Birmingham Co., Ansonia, Conn.
Farrell-Cheek Steel Co., Sandusky, Ohio.
Farris Engineering Corp., 400 Commercial Ave., Palisades Park, N. J.
Farris Flexible Valve Co., 400 Commercial Ave., Palisades Park, N.J. ADV. p 104, 105
Farval Corp., 3249 E. 80th St., Cleveland 4, Ohio. ADV. p 170
Fast's Coupling Dept., Koppers Co., 690 Scott St., Baltimore 3, Md.
Fate-Root-Heath Co., Plymouth, Ohio.
Fawick Airflex Co., 9919 Clinton Rd., Cleveland 11, Ohio.
Federal Bearings Co., The, Poughkeepsie, N. Y.
Federal Electric Products Co., 50 Paris St., Newark 5, N. J.
Federal-Mogul Corp., 11031 Shoemaker, Detroit 13, Mich.
Federal Motor Truck Co., 5780 Federal Ave., Detroit 9, Mich.
Federal Pacific Electric Co., 50 Paris St., Newark, N. J.
Federal Pipe & Tank Co., 6851 E. Marginal Way, Seattle, Wash.
Felt Products Mfg. Co., 1506 Carroll Ave., Chicago 7, Ill.
Femco Inc., Irwin, Pa.
Fen Machine Co., 1350 Babbitt Rd., Cleveland 17, Ohio.
Fenwick Mfg. Co., 134 Rome St., Newark 5, N. J.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Filer & Stowell Co., 147 E. Becker St., Milwaukee 7, Wis.
Filter Fabrics, 1279 W. 3rd St., Cleveland 13, Ohio.
Filtration Engineers, Inc., 155 Oraton St., Newark 4, N. J.
Firestone Tire & Rubber Co., 12 S. Main St., Akron, Ohio.
Firth Sterling, Inc., 3113-15 Forbes St., Pittsburgh 30, Pa.
Fisher Leather Belting Co., Inc., The, 325 N. 3rd St., Philadelphia 6, Pa.
Fisher & Porter Co., 415 Warminster Rd., Hatboro, Pa.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif. ADV. p 224
Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.
Fiske Bros. Refining Co., Lubriplate Div., 129 Lockwood St., Newark 5, N. J.
Fitzgibbons Boiler Co., 101 Park Ave., New York 17, N. Y.
Fitz Simons & Connell Dredge & Dock Co., 10 So. LaSalle St., Chicago 3, Ill.
Fletcher & Co., J. H., 7th & Madison Sts., Huntington, W. Va.
Flexaust Co., The, 100 Park Ave., New York 17, N. Y.
Flexible Steel Lacing Co., 4607 Lexington St., Chicago 44, Ill. ADV. p 200
Flexible Tubing Corp., Guilford, Conn.
Flexible Valve Corp., 400 Commercial Ave., Palisades Park, N. J.
Flexitalic Gasket Co., 926 — 8th St., Camden, N. J.
Flintkote Co., 30 Rockefeller Plaza, New York 26, N. Y.
Flocker & Co., John, 644 Grant St., Pittsburgh 19, Pa.
Flood City Brass & Electric Co., Johnstown, Pa.
Flory Mfg. Co., S., Bangor, Pa.
Flour Corp., 2500 S. Atlantic Blvd., Los Angeles 22, Calif.
The Fly Ash Arrestor Corp., P. O. Box 1883, Birmingham 1, Ala.
Foley Bros., Inc., Westchester Lighting Co. Bldg., Vermilyea St., Pleasantville, N. Y.
Food Machinery & Chemical Corp., 301 W. Avenue 26, Los Angeles 31, Calif.
Food Machinery & Chemical Corp., P. O. Box 552, Riverside, Calif.
Food Machinery & Chem. Corp., Westvaco Chemical Div., 161 E. 42nd St., New York 17, N. Y.
Foote Bros. Gear & Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill.
Ford Motor Co., P. O. Box 658, Dearborn, Mich.
Forker Corp., 2044 Random Rd., Cleveland 6, Ohio.
Formica Co., 4649 Spring Grove Ave., Cincinnati 32, Ohio.
Ft. Worth Steel & Machinery Co., P. O. Box 1038, Ft. Worth, Tex.
Forty Eight Insulations, Inc., Aurora, Ill.
Forty-Niner Corp., 5245 Grand River Ave., Detroit 8, Mich.
Foster Co., L. B., P. O. Box 1647, Pittsburgh 30, Pa.
Foster Engineering Co., 835 Lehigh Ave., Union, N. J.
Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.
Four-Wheel Drive Auto Co., Clintonville, Wis.
Foxboro Co., Foxboro, Mass.
Franklin Brass Foundry Co., Pear & Richmond Sts., Reading, Pa.
Franklin Plastics Co., 315 Grant St., Franklin, Pa.
Frantz Co., Inc., S. G., P. O. Box 1138, Trenton 6, N. J.
Frederick Iron & Steel Co., Frederick, Md.
Freedom-Valvoline Oil Co., Third Ave., Freedom, Pa.
Fretz-Moon Tube Co., Butler, Pa.
Frog, Switch & Mfg. Co., Carlisle, Pa.
Frontier Bronze Corp., New & Packard Roads, Niagara Falls, N. Y.
Frontier Industries, Manzel Div., 315 Babcock St., Buffalo 10, N. Y.
Fruehauf Trailer Co., 10940 Harper Ave., Detroit 32, Mich.
Fuel Process Co., D at 10th St., South Charleston, W. Va.
Fuller Co., Catasauqua, Pa.
Fuller Mfg. Co., Kalamazoo, Mich.
Fulton Bag & Cotton Mills, Inc., Canvas Div., P. O. Box 1726, Atlanta 1, Ga.
Fulton Foundry & Machine Co., Morgan Ave. at E. 75th St., Cleveland 27, O.
Fulton Iron Works Co., 1259 Delaware Ave., St. Louis, Mo.
Fyr-Fyter Co., 221 Crane St., Dayton, O.

G

G & W Electric Specialty Co., 7782 Dante Ave., Chicago 19, Ill.
Galigher Co., 545 W. 8th So. St., Salt Lake City 10, Utah.
Galion Allsteel Body Co., Galion, Ohio.
Galion Iron Works, Galion, Ohio.
Galland-Henning Mfg. Co., 2753 S. 31st St., Milwaukee 46, Wis.
Gardner-Denver Co., Quincy, Ill. ADV. p 125
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
Garlock Packing Co., 402 East Main St., Palmyra, N. Y.
Gar Wood Industries, Inc., Wayne, Mich.
Gar Wood Industries, Inc., St. Paul Hydraulic Hoist Div., Wayne, Mich.
Gate City Steel, Box 1487, Boise, Idaho.
Gates Rubber Co., The, 999 S. Broadway, Denver 17, Colo.
Gatke Corp., 246 N. La Salle St., Chicago 1, Ill.
Gear Specialties, Inc., 2635 W. Medill Ave., Chicago 47, Ill.
General American Transportation Corp., 135 S. LaSalle St., Chicago 90, Ill.
General Aniline & Film Corp., Ozalid Div., 400 Ozaway, Johnson City, N. Y.
General Cable Corp., 420 Lexington Ave., New York 17, N. Y.
General Dry Batteries, Inc., 18109 Athens Ave., Cleveland 7, Ohio.
General Dynamics Corp., Electro Dynamic Div., 163 Avenue A, Bayonne, N. J.
General Dynamics Corp., Electro Dynamic Div., Electric Boat Co., Avenue A & North St., Bayonne, N. J.
General Electric Co., Schenectady 5, N. Y.
General Electric Co., Apparatus Sales Div., Schenectady 5, New York.
General Electric Co., Carboloy Dept., 11173 E. 8 Mile Rd., Detroit 32, Mich.
General Electric Co., Chemical & Metallurgical Div., 1 Plastics Ave., Pittsfield, Mass.
General Electric Co., Const. Materials Div., 1285 Boston Ave., Bridgeport 2, Conn.
General Electric Co., Trumball Electric Dept., Plainville, Conn.
General Engineering Co., Ltd., 100 Adelaide St., W., Toronto 1, Canada.
General Equipment & Mfg. Co., 120 S. Campbell St., Louisville, Ky.
General Grinding Wheel Corp., 1500 Walnut St., Philadelphia 2, Pa.
General Metals Corp., Enterprise Engine & Machinery Div., 18th & Florida Sts., San Francisco 10, Calif.
General Mills, Inc., Fourth St. & Second Aves, Minneapolis, Minn.
General Motors Corp., Allison Division, Indianapolis 6, Ind. ADV. p 149
General Motors Corp., Chevrolet Div., General Motors Bldg., Detroit, Mich.
General Motors Corp., Delco Products Div., General Motors Corp., 329 E. First St., Dayton, Ohio.
General Motors Corp., Detroit Diesel Engine Div., 13400 W. Outer Dr., Detroit 28, Mich. ADV. p 149
General Motors Corp., Electromotive Div., La Grange, Ill.
General Motors Corp., Euclid Div., 1361 Chardon Rd., Cleveland 17, Ohio.
General Motors Corp., GMC Truck & Coach Div., 660 S. Blvd. E., Pontiac 11, Mich.
General Motors Corp., Hyatt Bearings Div., Harrison, N. J.
General Motors Corp., Moraine Products Div., 1550 Wisconsin Blvd., Dayton 1, Ohio.
General Motors Corp., New Departure Division, Bristol, Conn.
General Motors Overseas Operations, 1775 Broadway, New York 19, N. Y.
General Nuclear Corp., 550 - 5th Avenue, New York 36, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
General Refractories Co., 1520 Locust St., Philadelphia 2, Pa.
General Steel Warehouse Co., Inc., Genscos Tool Div., 1830 N. Kostner Ave., Chicago 39, Ill.
General Switch Corp., 45 Roebling St., Brooklyn 11, N. Y.
General Tire & Rubber Co., Akron 1, Ohio.
Geo-Optic Co., Inc., 170 Broadway, New York 38, N. Y.
Geophysical Instrument Co., 1820 N. Nash St., Arlington, Va.
Geophysical Instrument Co., Georator Corp. Div., Arlington 9, Va.
Geophysical Measurements Corp., 802-805 Wright Bldg., Tulsa 3, Okla.
Geophysical Services, Inc., 5900 Lemmon Ave., Dallas, Texas
Georgia Iron Works Co., 605—12th St., Augusta, Ga.
Getman Brothers, U. S. 31, South Haven, Mich.
Giant Grip Mfg. Co., 29 Osceola St., Oshkosh, Wis.
Giant Mfg. Co., Sixth St. & 12th Ave., Council Bluffs, Iowa
Gibraltar Equipment & Mfg. Co., P. O. Box 304, Alton, Ill.
Gilbreath Chemical Co., 383 Brannan St., San Francisco, Calif.
Gilmer Co., L. H., Cottman & Keystone Sts., Philadelphia 35, Pa.
Gilson Screen Co., 110 Center St., Malinta, Ohio
Gits Bros. Mfg. Co., 1846 S. Kilbourn Ave., Chicago 23, Ill.
Glidden Products Corp., Box 1191, Glendale 4, Calif.
E. A. Godoy & Co., Inc., 25 Broadway, New York, N.Y. ADV. p 172
Goggle Parts Co., 1468 W. 9th St., Cleveland 13, Ohio
Goldak Co., The, 1544 W. Glenoaks Blvd., Glendale 1, Calif.
Golden-Anderson Valve Specialty Co., Keenan Bldg., Pittsburgh 22, Pa.
Goodall Brothers, 46 S. Main St., Helena, Mont.
Goodall Rubber Co., Whitehead Rd., Trenton, N. J. ADV. p 126, 127
Goodman Mfg. Co., Mancha Storage Battery Locomotive Div., Halsted St. & 48th Pl., Chicago 9, Ill.
Goodrich Co., B. F., 500 S. Main St., Akron, Ohio
Goodyear Tire & Rubber Co., 1144 E. Market St., Akron 16, Ohio
Gorman-Rupp Co., Mansfield, Ohio
Gould & Co., Gordon L., 58 Sutter St., San Francisco 4, Calif. ADV. p 206
Gould-National Batteries, Inc., 467 Calhoun St., Trenton 7, N. J.
Goulds Pumps, Inc., Seneca Falls, N. Y.
Goyne Steam Pump Co., Ashland, Pa.
Graham-White Mfg. Co., Princeton Fdry. & Supply Div., Box 430, Princeton, W. Va.
Gramm Trailer Corp., Gramm Bldg., Lima, Ohio
Granberg Corp., 1308—67th St., Oakland 8, Calif.
Grant Gear Works, Inc., South Boston 27, Mass.
Graton & Knight Co., 356 Franklin St., Worcester 4, Mass.

Graver Tank & Mfg. Co., Inc., East Chicago, Indiana
Gray & Co., 60—11th Ave., N. E., Minneapolis 13, Minn.
Graybar Electric Co., Inc., 420 Lexington Ave., New York 17, N. Y.
Gray Instrument Co., 64½ W. Johnson St., Philadelphia 44, Pa.
Great American Industries, Inc., Connecticut Telephone & Electric Div., 70 Britannia St., Meriden, Conn.
Great Lakes Electrical Mfg. Co., 17 S. Desplaines St., Chicago, Ill.
Green Fire Brick Co., A. P., Mexico, Mo.
Green, Inc., R. H., 1201—24th St., Oakland, Calif.
Greene, Tweed, Co., North Wales, Pa.
Greensburg Machine Co., Greensburg, Pa.
Greenville Steel Car Corp., Greenville, Pa.
Gregg Co., Ltd., The, 19 Rector St., New York 6, N.Y. ADV. p 135
Gregory Mfg. Co., 67 Franklin St., New Haven 11, Conn.
Grinnell Co., Inc., 260 W. Exchange St., Providence 1, R. I.
Griphoist, Inc., 700 Polk St., San Francisco 9, California
Groch Engineering Co., 628 W. 9th St., Los Angeles 15, Calif.
Gruendler Crusher & Pulverizer Co., 2919 N. Market St., St. Louis 6, Mo.
Gulf Oil Corp., Gulf Bldg., Pittsburgh 30, Pa.
Gulick-Henderson Laboratories, Inc., 25 W. 43rd St., New York 18, N. Y.
Gundlach Machine Co., T. J., 226 Centerville Ave., Belleville, Ill.
Gurley, W. & L. E., 514 Fulton St., Troy, N. Y.
Gustin-Bacon Mfg. Co., 210 W. 10th St., Kansas City, Mo.
Guyan Machinery Co., 755 Stratton, Logan, W. Va.
Gwilliam Co., 360 Furman St., Brooklyn 2, N. Y.

H

H & L Tooth Co., Box 330-B, Montebello, Calif.
Hack Engineering Co., 124 Wazee Market, Denver, Colo.
Hagan Co., George J., 2400 E. Carson St., Pittsburgh 3, Pa.
Hagen Corporation, Hagan Bldg., Pittsburgh 30, Pa.
Hales Co., W. M., Box 65, 700 Commerce St., Danville, Ill.
Hall & Sons, Amos H., 5500 N. Water St., Philadelphia 20, Pa.
Hallett Manufacturing Co., 1601 W. Florence Ave., Inglewood, Calif.
Halross Instruments Corp., Ltd., 171 Garry St., Winnipeg, Manitoba, Canada
Hamilton Rubber Mfg. Corp., Mead St., Trenton, N. J.
Hamer Valves, Inc., 2919 Gardenia Ave., Long Beach 6, California
Hammond Bag & Paper Co., Wellsburg, W. Va.
Hammond Co., J. V., Spangler, Pa. ADV. p 219
Handy & Harman, 82 Fulton St., New York 38, N. Y.
Hanks, Inc., Abbot A., 624 Sacramento St., San Francisco 11, Calif.
Hanlon & Wilson Co., 325 Pennwood Ave., Pittsburgh 21, Pa.
Hannon & Sons, F. R., Canton 7, Ohio
Hanson Clutch & Machinery Co., Wall & Miami Sts., Tiffin, Ohio
Hapman-Dutton Co., Hapman Conveyors, Inc. Div., 630 Gibson St., Kalamazoo, Mich.
Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh 22, Pa.
Hardie-Tynes Mfg. Co., 800 N. 28th St., Birmingham, Ala.
Hardinge Co., Inc., 240 Arch St., York, Pa. ADV. p 108, 109
Hardsocg Div., Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.
Harnischfeger Corp., 4400 N. National Ave., Milwaukee 46, Wis. ADV. Third Cover
Harnischfeger Corp., P & H Diesel Div., Crystal Lake, Ill.
Harper Electric Furnace Corp., Niagara Falls, N. Y.
Harrington Co., 17th & Callowhill Sts., Philadelphia 30, Pa.
Harrington & King Perforating Co., 5655 Filmore St., Chicago 44, Ill.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.
Hartwell & Son, Inc., H. N., Park Square Bldg., Boston, Mass.
Haslett Chute & Conveyor Co., Oaks, Pa.
Hatheway & Co., 75 Montgomery St., Jersey City, 2, N. J.
Hauck Manufacturing Co., 126 Tenth St., Brooklyn 15, N. Y.
Hauser-Stander Tank Co., 4820 Spring Grove Ave., Cincinnati 32, Ohio
Havlick Diamond Drilling Co., Inc., 2703 N. Pittsburg St., Spokane 26, Wash.
Hawley & Hawley, Douglas, Ariz.
Hawthorne, Inc., Herb J., Box 7366, Houston 8, Tex.
Hayes Steel Products, Ltd., Merritton, Ontario, Canada
Hayes Track Appliance Co., 120 N. 3rd St., Richmond, Ind.
Hayward Co., 50 Church St., New York, N. Y.
H-B Instrument Co., Inc., American & Bristol Sts., Philadelphia 40, Pa.
Heiland Research Corp., 130 E. 5th Ave., Denver 9, Colo.
Heil Co., 3000 W. Montana St., Milwaukee 1, Wis.
Heim Co., 46 Sanford St., Fairfield, Conn.
Heineken, Inc., W. P., 50 Broad St., New York, N. Y.
Heinemann Electric Co., 98 Plum St., Trenton 2, N. J.
Heintz & Co., James C., 3738 W. 143rd St., Cleveland 11, Ohio
Hein-Werner Corp., Waukesha, Wis.
Helmick Foundry-Machine Co., P. O. Box 71, Fairmont, W. Va.
Helwig Co., 2544 N. 30th St., Milwaukee 10, Wis.
Hendrick Mfg. Co., Carbondale, Pa.
Hendrickson Mfg. Co., 8001 W. 47th St., Lyons, Ill.
Hendrix Mfg. Co., Mansfield, La.
Herbach & Rademan, Inc., 522 Market St., Philadelphia 6, Pa.
Hercules Motors Corp., 101-11th St., S. E., Canton 2, Ohio
Hercules Powder Co., Delaware Trust Bldg., Wilmington, Del.
Hercules Steel Products Corp., Galion, Ohio
Herman, John 920 Santee St. Los Angeles 15 Calif.
Herold Mfg. Co.. 215 Hickory St., Scranton 5, Pa.
Hertner Electric Co., 12690 Elmwood Ave., N. W., Cleveland 11, Ohio
Hevi Duty Electric Co., 4212 W. Highland Blvd., Milwaukee 1, Wis.
Hewitt Metals Corp., Stanley Ave. at 12th St., Detroit 8, Mich.
Hewitt-Robins, Inc., 66 Glenbrook Rd., Stamford, Conn. ADV. p 168, 169
Hewitt-Robins, Inc., Hewitt Rubber Div., 240 Kensington Ave., Buffalo 5, N. Y.
Hewitt-Robins, Inc., Robins Conveyors Div., 270 Passaic Ave., Passaic, N. J.
Heyl & Patterson, Inc., 55 Fort Pitt Blvd., Pittsburgh 22, Pa. ADV. p 99
High Tension Co., 36 N. Main St., Phillipsburg, N. J.
Hill & Jude, Assayers, 800 Pearl St., Boulder, Colo.
Hillman Co., C. Kirk, 3201 First Ave., South Seattle 4, Wash.
Hills-McCanna Co., 3025 N. Western Ave., Chicago 18, Ill.
Hirsch Bros. Machy. Co., P. O. Box 226, El Paso, Tex.
Hisey-Wolf Machine Co., Colerain & Marshall Aves., Cincinnati 25, Ohio
Hi-Voltage Equipment Co., 4000 E. 116th St., Cleveland, Ohio
Hobart Bros. Co., Troy, Ohio
Hockensmith Corp., Penn, Pa.
Hockensmith Corp., Penn Body Div., Penn, Pa.
Hoffman Bros. Drilling Mfg. Co., Punxsutawney, Pa. ADV. p 219
Hoffman Combustion Engineering Co., Marquette Bldg., Detroit, Mich.
Holly Pneumatic Systems, Inc., 15 E. 40th St., New York 16, N. Y.
Holman Bros., Ltd., Camborne, Cornwall, England
Holman Bros. (Canada) Ltd., Kent Ave., Kitchener, Ontario, Canada.
Holmes & Bros., Inc., Robert, 570 Junction Ave., Danville, Ill.
Holtite Mfg. Co., Warner & Ostend Sts., Baltimore 30, Md.
Homelite Corp., 75 Riverdale Ave., Port Chester, N. Y.
Homer Mfg. Co., Lima, Ohio
Homestead Valve Mfg. Co., P. O. Box 348, Coraopolis, Pa.
Honan-Crane Corp., 215 Wabash Ave., Lebanon, Ind.
Honan-Crane Corp., Houdaille-Hershey Corp., 215 Wabash Ave., Lebanon, Ind.
Hose Accessories Co., 17th St. & Lehigh Ave., Philadelphia 32, Pa.
Hose-McCann Telephone Co., 25th St. & 3rd Ave., Brooklyn 32, N. Y.
Hoskins Mfg. Co., 4447 Lawton Ave., Detroit 8, Mich.
Hossfeld Mfg. Co., Winona, Minn. ADV. p 209
Hough Co., Frank G., 737 Fairview Ave., Libertyville, Ill.
Houghton & Co., E. F., 303 W. Lehigh Ave., Philadelphia 33, Pa.
House & Sons, Inc., Chas. W., Unionville, Conn.
Houston Technical Laboratories, 2424 Branard, Houston 6, Texas
Howe Scale Co., Rutland, Vt.
Howell Electric Motors Co., Howell, Mich.
Howells Mining Drill Co., Plymouth, Pa.
Hoyland Steel Co., 5104 Chrysler Bldg., 405 Lexington Ave., New York 17, N.Y.
Hoyt Wire Cloth Co., Box 22, Lancaster, Pa.
Hubbard & Co., Fulton Tool Works Div., Huntington, W. Va.
Hudson Engineering Corp., 2711 Danville, Houston, Texas
Hughes Tool Co., 300 Hughes, Houston, Texas
Hulburt Oil & Grease Co., Trenton & Castor Aves., Philadelphia 34, Pa.
Hulson Grate Co., 21 S. 9th St., Keokuk, Iowa
Humphreys Investment Co., Engineering Div., 915 First National Bank Bldg., Denver 2, Colo. ADV. p 156
Hunter Spring Co., Lansdale, Pa.
Huwood-Irwin Corp., P. O. Box 311, Irwin, Pa.
Hycon Aerial Surveys, Inc., 1020 S. Arroyo Pkwy, Pasadena 13, Calif.
Hydraulic Supply Mfg Co., 7500-8th Ave., S., Seattle, Wash.
Hydrotator Co., 80 N. Church St., Hazleton, Pa.
Hyman-Michaels Co., 2200 Jerrold Ave., San Francisco 24, Calif.
Hypro Engineering, Inc., 404 N. Washington Ave., Minneapolis, Minn.
Hyster Co., 2965 N. E. Clackamas St., Box 4318, Portland 8, Ore.

I

Ideal Electric & Mfg. Co., Mansfield, Ohio.
Ideal Industries, Inc., 1020 Park Ave., Sycamore, Ill.
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago 41, Ill.
Illinois Iron & Bolt Co., 1932 Thomas St., Carpentersville, Ill.
Illinois Powder Mfg. Co., 506 Olive St., St. Louis 1, Mo.
Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.
Illinois Zinc Co., 2959 W. 47th St., Chicago 32, Ill.
Imperial Cantrell Mfg. Co., 110 London Ave., Jellico, Tenn.
Imperial Electric Co., 63 Ira Ave., Akron 9, Ohio
Independent Explosives Co. of Pennsylvania, 304 Rehrig Bldg., Scranton 3, Pa.
Independent Pneumatic Tool Co., Aurora, Ill.
Indiana Foundry Co., Indiana, Pa.
Indiana Oxygen Co., 435 S. Delaware St., Indianapolis 6, Ind.
Industrial Air Products Co., 3200 N.W. Yeon Ave., Portland 10, Ore.
Industrial Brownhoist Corp., Bay City, Mich.
Industrial Engineering & Construction Co., P.O. Box 446, Fairmont, West Va.
Industrial Gloves Co., 700 Garfield St., Danville, Ill.

Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio
Industrial Oil Products Corp., Margaret and Pearce, Philadelphia, Pa.
Industrial Overlay Metals, Inc., 410 N. Barron St., Eaton, Ohio
Industrial Physics & Electronics Co., 329—5th Ave., Salt Lake City 3, Utah. ADV. p 200
Industrial Wire Cloth Products Corp., 4th & Brush Sts., Wayne, Mich.
Infilco, Inc., 2750 S. 12th Ave., Tucson, Ariz.
Ingalls Iron Works Co., Birmingham, Ala.
Ingersoll-Rand Co., Phillipsburg, N. J. ADV. p 100, 101
Inland Steel Co., 38 S. Dearborn St., Chicago 3, Ill.
Inland Steel Products Co., 4101 W. Burnham St., Milwaukee 1, Wis.
Insley Manufacturing Corp., Box 167, Indianapolis 6, Ind.
Insulated Duct & Cable Co., Stokes Ave., Trenton 5, N.J.
Insulatine Co., 1 Broadway, New York, N.Y.
Insul-Mastic Corp. of America, 1141 Oliver Bldg., Pittsburgh 22, Pa.
Intelligiant Corp., 1247 Westlake North, Seattle 9, Wash.
International Business Machine Corp., 590 Madison Ave., New York 22, N.Y.
International Combustion, Ltd., 19 Woburn Place, London W. C. 1, England
International Engineering, Inc., 1145 Bolander Ave., Dayton 1, Ohio
International Engineering Works, Framingham, Mass.
International General Electric Co., 570 Park Ave., New York, N.Y.
International Harvester Co., 180 No. Michigan Ave., Chicago 1, Ill.
International Harvester Co., Motor Truck Div., 180 North Michigan Ave., Chicago 1, Ill.
International Harvester Export Co., 180 N. Michigan Ave., Chicago 1, Ill.
International Minerals & Metals Corp., 11 Broadway, New York 4, N. Y. ADV. p 180
International Nickel Co., 67 Wall St., New York, N.Y.
International Paper Co., 220 E. 42nd St., New York 17, N.Y.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
International Salt Co., Scranton 2, Pa.
International Shoe Co., 1509 Washington Ave., St. Louis 3, Mo.
International-Stacey Corp., International Derrick & Equipment Div., 875 Michigan Ave., Columbus, Ohio
Interstate Drop Forge Co., 4051 27th St., Milwaukee, Wis.
Iowa Mfg. Co., 916—16th St., N.E., Cedar Rapids, Iowa. ADV. p 201
Ironton Engine Co., Farmingdale, N.J.
Ironton Fire Brick Co., Ironton, Ohio
Irving Subway Grating Co., 27th St., 49th & 50th Aves., Long Island City 1, N.Y.
Irwin Foundry & Mine Car Co., Irwin, Pa.
Isaacson Iron Works, Inc., Seattle 14, Wash.
Isbell Construction Co., P.O. Box 2351 S. Va. Rd., Reno, Nevada.
I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa.
I-T-E Circuit Breaker Co., Railway & Industrial Equipment Div., Greensburg, Pa.

J

Jacuzzi Bros., Inc., Richmond, Calif.
Jaeger Machine Co., 550 W. Spring St., Columbus 16, Ohio
James Equipment, Inc., 35 E. Runyon St., Newark 5, N.J.
James Mfg. Co., D. O., 1114 W. Monroe St., Chicago, Ill.
Janette Mfg. Co., 558 W. Monroe St., Chicago 6, Ill.
Jarrell-Ash Co., 28 Farwell St., Newtonville 60, Mass.
Jefferson Electric Co., Bellwood, Ill.
Jefferson Union Co., 601 W. 26th St., New York 1, N.Y.
Jeffrey Mfg. Co., 962 N. 4th St., Columbus, Ohio
Jenkins Bros., 100 Park Ave., New York 17, N.Y.
Jennison-Wright Co., Kreolite Bldg., Toledo, Ohio
Jesco Lubricants Co., P.O. Box 7331, Kansas City 16, Missouri
Jessop Steel Co., 538 Green St., Washington, Pa.
Jet-Lube, Inc., 3093 North California St., Burbank, Calif.
Johns-Manville, 22 E. 40th St., New York 16, N.Y.
Johnson Belting Co., 44 Hubert St., New York 13, N.Y.
Johnson Block Co., 501 S. Rockford St., P.O. Box 1432, Tulsa, Okla.
Johnson Bronze Co., 492 S. Mill St., New Castle, Pa.
Johnson Co., C. S., Champaign, Ill.
Johnson Corp., 816 Wood St., Three Rivers, Mich.
Johnson Loading Supplies, G. R., 5026 Butterworth Rd., Mercer Island, Wash.
Johnson Machine Co., Carlyle, 52 Main St., Manchester, Conn.
Johnson Mfg. Co., Fox Ave. & Holly St., Seattle 8, Wash.
Johnson-March Corp., 1724 Chestnut St., Philadelphia 3, Pa.
Johnson Plastic Corp., 201 Brown Rd., Chagrin Falls, Ohio
Johnson Co., The R. G., 831 Wash., Trust Bldg., Washington, Pa.
Johnston-Morehouse-Dickey Co., 704—2nd Ave., Pittsburgh 19, Pa.
Johnston Pump Co., 3272 E. Foothill Blvd., Pasadena 8, Calif.
Jones Co., T. R., Wilkes-Barre, Pa.
Jones Foundry & Machine Co., W. A., 4401 W. Roosevelt Road, Chicago 24, Ill. Adv. p. 188
Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa. ADV. p 139
Joslyn Mfg. & Supply Co., 20 N. Wacker Dr., Chicago 6, Ill.
Joyce-Cridland Co., 2027 E. First St., Dayton, Ohio
Joy Mfg. Co., Henry W. Oliver Bldg., Pittsburg 22, Pa. ADV. p 106, 107
Judd & Sons, J. D., Shullsburg, Wisconsin
Judsen Rubber Works, Inc., 4107 West Kinzie St., Chicago, Ill.
Justrite Mfg. Co., 2061 Southport Ave., Chicago 14, Ill.

K

KW Battery Co., 3705-33 Lincoln Ave., Chicago 13, Ill.
Kaiser Aluminum & Chemical Co., 1924 Broadway, Oakland 12, Calif.
Kaiser Engineers, 1924 Broadway, Oakland, California
Kanawha Mfg. Co., 1520 Dixie St., Charleston 1, W. Va.
Kato Engineering Co., Mankato, Minn.
Kaydon Engineering Corp., Muskegon, Mich.
Kearney Corp., James R., 4236 Clayton Ave., St. Louis 10, Mo.
Keasbey & Mattison Co., Ambler, Pa.
Keeney Co., Paul E., Weatherly Bldg., Portland 14, Ore.
Kellems Co., 15 Williams St., Stonington, Conn.
Keller Co., E., 238 West St., Williamsport 3, Pa.
Kelley, John E., 207 Capitol Towers, Washington 2, D.C.
Kelley & Co., O. G., 98 Taylor St., Boston 22, Mass.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kelly Foundry & Machine Co., 614—9th St., Goshen, Ind.
Kelly-Koett Manufacturing Co., 12 E. 6th St., Covington, Ky.
Kennametal, Inc., Latrobe, Pa.
Kennedy Valve Mfg. Co., Elmira, N.Y.
Kennedy-Van Saun Mfg. & Eng. Corp., 2 Park Ave., New York, N. Y. ADV. p 157
Ken Research, Inc., 831 5th Ave., River Edge 18, N. J. ADV. p 193
Kensington Steel Co., 505 Kensington Ave., Chicago 28, Ill.
Kenworth Motor Truck Corp., 8801 E. Marginal Way, Seattle 8, Wash.
Kenyon Machinery Co., 635 Walnut St., Denver 4, Colo.
Kerite Co., 30 Church St., New York 7, N.Y.
Kerlow Steel Flooring Co., 222 Culver Ave., Jersey City 5, N.J.
Kern Co., John A., 224 N. Loomis St., Chicago 7, Ill.
Kern Instruments, Inc., P.O. Box 727, White Plains, N.Y.
Kerrigan Iron Works, Inc., 1033 Herman St., Nashville 2, Tenn.
Kersey Mfg. Co., P.O. Box 150, Bluefield, Va.
Keuffel & Esser Co., 30 Adams St., Hoboken, N.J.
Kewanee-Ross Corp., 1407 West Ave., Buffalo 13, N.Y.
Keystone Carbon Co., 1933 State St., St. Marys, Pa.
Keystone Driller Co., 2021—8th Ave., Beaver Falls, Pa.
Keystone Lubricating Co., 21st & Clearfield Sts., Philadelphia 32, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Walter Kidde & Co., Inc., 756 Main St., Belleville 9, N.J.
Kieley & Mueller, Inc., 2033—43rd St., North Bergen, N.J.
Kilbourne & Jacobs Mfg. Co., Columbus 16, Ohio
Kilby, V. Claiborne, Milton, N.C.
Killark Electric Mfg. Co., 3940 Easton Ave., St. Louis, Mo.
King Powder Co., 1703 First National Bank Bldg., Cincinnati 2, Ohio
Kirk & Blum Mfg. Co., 3100 Forrer St., Cincinnati 9, Ohio
Klein & Sons, Mathias, 3200 Belmont Ave., Chicago 18, Ill.
Klemp Co., Wm. F., 6601 S. Melvina Ave., Chicago, Ill.
Klipfel Valves, Inc., 1000 Weller Ave., Hamilton, Ohio
Klockner-Humboldt-Deutz AG, c/o Diesel Energy Corp. 143 Liberty St., N.Y. 6 N. Y.
Knox Mfg. Co., 222 W. Clinton St., Oaklyn, N.J.
Koebel Diamond Tool Co., 9456 Grinnell, Detroit 13, Mich.
Koehring Co., 31st & Concordia Ave., Milwaukee 10, Wis.
Kohler Co., Kohler, Wis.
Kolton Electric Mfg. Co., 128 New Jersey R. R. Ave., Newark 5, N. J.
Komline-Sanderson Engineering Corp., Peapack, N. J.
Kondu Corp., 1040 W. 12th St., Erie, Pa.
Koppers Co., Inc., Fast's Coupling Dept., 690 Scott St., Baltimore 3, Md.
Koppers Co., Inc., Metal Prod. Div., 200 Scott St., Baltimore 30, Md.
Koppers Co., Inc., Wood Preserving Div. & Tar Products Div., Koppers Bldg., Pittsburgh 19, Pa.
Korb-Pettit Wire Fabrics & Iron Works, Inc., 1505-15 N. Mascher St., Philadelphia 22, Pa.
Kremser & Sons, Inc., Frank A., 3435 N. 5th St., Philadelphia, Pa.
Krogh Pump & Equipment Co., 515 Harrison St., San Francisco, Calif.
Kuhlman Electric Co., 26th & Jefferson Sts., Bay City, Mich.
Kuljian Corp., 1200 N. Broad St., Philadelphia, Pa.
Kurz & Root Co., 232 E. North Island St., Appleton, Wis.

L

LaBour Co., 1607 Sterling Ave., Elkhart, Ind.
Laclede-Christy Clay Products Co., Ambassador Bldg., St. Louis 1, Mo.
Laclede Steel Co., Arcade Bldg., St. Louis, Mo.
LaCrosse Trailer Corp., La Crosse, Wis.
Ladish Co., Cudahy, Wis.
Lake City Malleable Co., 5000 Lakeside Ave., Cleveland 14, Ohio
Lake Shore Electric Mfg. Corp., 2400 Woodland Ave., Cleveland 15, Ohio
Lake Shore Engineering Co., Iron Mountain, Mich.
Lakeside Bridge & Steel Co., 5300 N. 33rd St., Milwaukee 9, Wis.
Lamb Electric Co., Kent, Ohio
Lamson Corp., Allen Billmyre Div., 210 Lamson St., Syracuse 1, N. Y.
Lamson & Sessions Co., The, 1971 West 85th St., Cleveland 2, Ohio
Landis Steel Co., 116 West A St., Box 248, Picher, Okla.
Latrobe Electric Steel Co., Latrobe, Pa.

Lattimer Foundry & Machine Co., Lattimer Mines, Pa.
Laubenstein Mfg. Co., 422 S. 3rd St., Ashland, Pa.
Laughlin Co., Thomas (now Div. of Amer. Hoist & Derrick Co.), 143 Fore St., Portland 6, Maine
Laux & Sons Mfg. Co., Jacob, Shavertown, Pa.
Lawrence Machine & Pump Corp., 383 Market St., Lawrence, Mass.
Lawrence Pump & Engine Co., Canal & Marston Sts., Lawrence, Mass.
Lawrence Pumps, Inc., 371 Market St., Lawrence, Mass.
Laylander, Philip A., Box 241, Fallon, Nev.
Layne & Bowler, Inc., Box 6697, Memphis 8, Tenn.
Leach Corp., Inet Div., 4441 So. Santa Fe Ave., Los Angeles 58, Calif.
Leach Corp., Palmer Electric Mfg. Co. Div., 6629 Bear Ave., Bell, Calif.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.
Lead Lined Iron Pipe Co., 1 Broadway, Wakefield, Mass.
Lebanon Steel Foundry, Lebanon, Pa.
LeBus Rotary Tool Works, Longview, Tex.
Lecco Engineering & Manufacturing Co., Box 3183, Bluefield, W. Va.
Lecourtenay Co., 30 Rockefeller Plaza, New York 20, N. Y.
Ledeen Mfg. Co., 1606 S. San Pedro St., Los Angeles, Calif.
Ledoux & Co., 359 Alfred Ave., Teaneck, N. J. ADV. p 219
Leeds & Northrup Co., 4918 Stenton Ave., Philadelphia 44, Pa.
Lee-Norse Co., Charleroi, Pa.
Lee Rubber & Tire Corp., Republic Rubber Div., Albert St., Youngstown, Ohio
Leetonia Tool Co., 142 Main St., Leetonia, Ohio
Leffel & Co., James, The, Springfield, Ohio
Lehigh Safety Shoe Co., First & Minor Sts., Emmaus, Pa.
Leonard Electric Mfg. Co., 3907 Perkins Ave., Cleveland 14, Ohio
Leschen Wire Rope Div., H. K. Porter Co., 2727 Hamilton Ave., St. Louis 12, Mo.
Le Tourneau-Westinghouse Co., P. O. Box 240, Peoria, Ill.
Leupold & Stevens Instruments, Inc., 4445 N.E. Glisan St., Portland 13, Ore.
Lewellen Mfg. Co., 10th St. & Werner Ave., Columbus, Ind.
Lewis Bolt & Nut Co., 504 Malcolm Ave., S.E., Minneapolis 14, Minn.
Lewis Electrical Mfg. Co., 1943 Walton Ave., New York, N. Y.
Lidgerwood Industries, Inc., 7 Dey St., New York, N. Y.
Lilie-Hoffman Cooling Towers, Inc., 4239 Duncan Ave., St. Louis 10, Mo.
Lima Electric Motor Co., The, Findlay Rd., Lima, Ohio
Linatex Corp. of America, Rockville, Conn.
Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio
Lincoln Engineering Co., 5701 Natural Bridge, St. Louis 20, Mo.
Lindbergh Engrg. Co., Fisher Furnace Div., 2450 W. Hubbard St., Chicago, Ill.
Line Material Co., 700 W. Michigan St., Milwaukee 1, Wis.
Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. ADV. p 121
Link-Belt Speeder Corp., Cedar Rapids, Iowa
Linn Manufacturing Corp., Morris, N. Y.
Lippmann Engineering Works, 4603 W. Mitchell St., Milwaukee, Wis. ADV. p 147
Lisbon Hoist & Crane Co., Lisbon, Ohio
Lister-Blackstone, Inc., 420 Lexington Ave., New York 17, N. Y.
Little Giant Crane & Shovel Co., Des Moines 13, Iowa
Lockrey Co., Southhampton, N. Y.
Logan Engineering Co., 4901 W. Lawrence Ave., Chicago 30, Ill. ADV. p 146
The Lombard Governor Corp., Main St., Ashland, Mass.
Lonergan Co., J. E., 2nd & Race Sts., Philadelphia 6, Pa.
Long Company, The, Box 331, Oak Hill, W. Va. ADV. p 174
Longyear Co., E. J., 1700 Foshay Tower, Minneapolis 2, Minn. ADV. p 204
Loomis Machine Co., 17 E. Market St., Tiffin 15, Ohio
Los Angeles Steel Casting Co., 6100 South Boyle, Los Angeles 58, Calif.
Louden Machinery Co., 607 Broadway, Fairfield, Iowa
Louisville Electric Mfg. Co., 31st & Magazine Sts., Louisville, Ky.
Lovejoy Flexible Coupling Co., 4835 W. Lake St., Chicago 44, Ill.
Lowell Insulated Wire Co., 171 Lincoln St., Lowell, Mass.
Ludlow-Saylor Wire Co., 634 S. Newstead, St. Louis 10, Mo.
Lufkin Rule Co., Saginaw, Mich.
Lug-All Co., 355 E. Lancaster, Haverford, Pa.
Lukens Steel Co., Coatesville, Pa.
Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N. Y.
Lundberg Explorations, Ltd., 80 Richmond West, Toronto, Ontario, Canada
Lunkenheimer Co., The, Beekman St. & Waverly Ave., Cincinnati 14, Ohio
Luzerne Rubber Co., Muirhead & Dewey Sts., Trenton 7, N. J.

M

M & H Valve & Fittings Co., Anniston, Ala.
M & M Woodworking Co., 2301 North Columbia Blvd., Portland, Ore.
Macbeth Daylighting Corp., Newburgh, N. Y.
MacClatchie Mfg. Co., Compton, Calif.
Mace Co., 2763 Blake St., Denver 5, Colo.
Macklin Co., 1936 Lawrence Blvd., Jackson, Mich.
Macklin Equipment Co., 520 Harbor Blvd., W. Sacramento, Calif.
Macleod Co., 2240 Bogen St., Cincinnati 22, Ohio
Machinery Center, Inc., 808 Newhouse Bldg., Salt Lake City 1, Utah. ADV. p 222
Macmillan Petroleum Corp., 530 W. 6th St., Los Angeles 14, Calif.
Mack Trucks, Inc., 350 Fifth Ave., New York 1, N.Y. ADV. p 124
MacWhyte Co., 2937—14th Ave., Kenosha, Wis.
Maddox Foundry & Machine Works, Inc., Archer, Fla.
Madesco Tackle Block Co., Easton, Pa.
Magnetic Engineering & Mfg. Co., 852 Van Houten Ave., Clifton, N. J.
Magnolia Metal Co., 18 W. Jersey St., Elizabeth 4, N. J.
W. R. Magnus, Inc., 188 West Randolf St., Chicago, Illinois
Magor Car Corp., 50 Church St., New York 7, N.Y. ADV. p 177
Mahon Co., R. C., P.O. Box 4666, Detroit 34, Mich.
Mahr Mfg. Co., 1728—2nd St., N., Minneapolis 11, Minn.
Majac, Inc., 23rd St., Sharpsburg 15, Pa. ADV. p 176
Malleable Iron Fittings Co., Maple St., Granford, Conn.
Mallinckrodt Chemical Works, 2nd & Mallinckrodt Sts., St. Louis 7, Mo.
Manganese Steel Forge Co., Allen St. & Castor Ave., Philadelphia 34, Pa.
Manheim Mfg. & Belting Co., Manheim, Pa.
Manierre Engineering & Machinery Co., 759 N. Milwaukee St., Milwaukee 2, Wis.
Manistee Iron Works Co., Manistee, Mich.
Manitoba Steel Foundries, Ltd., Selkirk, Manitoba, Canada.
Manitowoc Engineering Corp., South 16th St., Manitowoc, Wis.
Manning, Maxwell & Moore, Inc., 11 Elias St., Bridgeport 2, Conn.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Div., Muskegon, Mich.
Manu-Mine Research & Devel. Co., P.O. Box 167, Reading, Pa.
Marathon Coal Bit Co., Montgomery, W. Va.
Marathon Corp., Chem. Div., Box 557, Rothschild, Wis.
Marathon Electric Mfg. Corp., Wausau, Wis.
Marble Card Electric Corp., Superior St., Gladstone, Mich.
Marion Metal Products Co., Cheney Ave., Marion, Ohio.
Marion Power Shovel Co., Marion, Ohio
Maris Crane & Hoist Co., 1441 S. 37th St., Philadelphia 46, Pa.
Mark & Co., Clayton, 1900 Dempster St., Evanston, Ill.
Markley Dust Control System, Inc., 80 Snyder Rd., Ramsey, N. J.
Marland One-Way Clutch Co., 561 Hillgrove Ave., La Grange, Illinois
Marley Co., Fairfax & Marley Rds., Kansas City 15, Kan.
Marlin-Rockwell Corp., 402 Chandler St., Jamestown, N. Y.
Marlow Pumps, 548 Greenwood Ave., Ridgewood, N. J.
Marmon-Harrington Co., 1511 W. Washington St., Indianapolis 7, Ind.
Marquette Mfg. Co., Inc., 307 E. Hennepin Ave., Minneapolis 14, Minn.
Marsh Engineering Co., E. F., 4324 W. Clayton Ave., St. Louis 10, Mo.
Martindale Electric Co., 1332 Hird Ave., Cleveland 7, Ohio
Martin Engineering Co., Neponset, Ill.
Martin Fan & Blower Co., 4634 W. 21st Pl., Chicago 50, Ill.
Marvel Engineering Co., 625 West Jackson Blvd., Chicago 6, Ill.
Massachusetts Gear & Tool Co., 30 Nashua St., Woburn, Mass.
Master Builders Co., 7016 Euclid Ave., Cleveland 3, Ohio
Master Electric Co., Dayton 1, Ohio
Master Mfg. Co., Hutchinson, Kan.
Master Vibrator Co., 100 Davis Ave., Dayton 1, Ohio
Mather & Sons, George, OK Machinery Div., Columbia, Pa.
Matheson Co., 327 Paterson Plank Rd., East Rutherford, N. J.
Mathews Conveyor Co., 198—10th St., Ellwood City, Pa.
Mavor & Coulson Ltd., Bridgeton, Glasgow, S.E., Scotland
Maximon Machine Co., Altoona, Pa.
Maxon Construction Co., 131 N. Ludlow St. Dayton, Ohio
Mayhew Supply Co., 4700 Scyane Rd., P. O. Box 7726, Dallas, Tex. ADV. p 128
Mayo Tunnel & Mine Equipment Co., Box 1413, Lancaster, Pa.
M-B Products, 130 E. Larned St., Detroit 26.
McCabe-Powers Auto Body Co., 5900 block N. Broadway, St. Louis 15, Mo.
McClintock Co., R. S., W. 418—2nd Ave., Spokane, Wash.
McCollum Hoist & Mfg. Co., 719 Rogers St., Downers Grove, Ill.
McCord Corp., 2587 E. Grand Blvd., Detroit 11, Mich.
McCulloch Motors Corp., 6101 West Century Blvd., Los Angeles 45, Calif.
McDonald Co., B. F., 5721 W. 96th St., Los Angeles 45, Calif.
McDonald Drilling Co., Middlesboro, Ky.
McDonald Mfg. Co., A. Y., 12th & Pine Sts., Dubuque, Iowa
McDonald, T. J., 14408 St. Marys, Detroit 27, Mich.
McFarlane-Eggers Machinery Co., 2763 Blake St., Denver, Colo.
McGann Mfg. Co., York, Pa.
McGill Mfg. Co., 1151 N. Lafayette St., Valparaiso, Ind.
McGowan Co., John H., Leyman Mfg. Corp. Div., 58 Central Ave., Cincinnati 2, Ohio
F. H. McGraw Co., 51 East 42nd St., New York, N. Y.
McKay Co., York, Pa.
McKiernan-Terry Corp., 15 Park Row, New York, N. Y.
McKiernan-Terry Corp., Pile Hammer Div., 15 Park Row, New York 38, N. Y.
McKinney Drilling Co., P.O. Box 190, Nacogdoches, Texas
McKissick Products Co., 2855 Dawson Rd., Tulsa, Okla.
McLanahan & Stone Corp., Hollidaysburg, Pa.
McLaughlin Mfg. Co., Joliet, Ill.
McLeod & Henry Co., 357 First St., Troy, N. Y.
McMillan's Sons, W. H., 49 South St., New York, N. Y.
McNally Pittsburg Mfg. Corp., 307 W. 3rd St., Pittsburg, Kansas
McWane Cast Iron Pipe Co., 1203 Vanderbilt Rd., Birmingham 2, Ala.
Mead Mill Co., 14620 E. Seven Mile Rd., Detroit 5, Mich.
Mechanical Industries, Inc., 541 Wood St., Pittsburgh 22, Pa.
Meckum Engineering, Inc., 53 W. Jackson Blvd., Chicago 3, Ill.
Medart Co., 1 Potomac St., St. Louis 18, Mo.
Mechanite Metal Corp., 271 North Ave., New Rochelle, N. Y.
Meeker Foundry Co., 95 Clay St., Newark 4, N. J.
Memco Engineering & Mfg. Co., Commack, Long Island, N. Y.
Menlo Research Laboratory, P.O. Box 522, Menlo Park, Calif.
Merck & Co., Rahway, N. J.

Merco Nordstrom Valve Co., 400 Lexington Ave., Pittsburgh, Pa.
Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio
Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.
Merrick Scale Mfg. Co., 184 Autumn St., Passaic, N. J.
Merrill Co., 582 Market St., San Francisco.
Merrow Machine Co., 2829 Laurel St., Hartford 6, Conn.
Metal Carbides Corp., 107 East Indianola Ave., Youngstown 7, Ohio
Metal & Thermit Corp., 100 E. 42nd St., New York, N. Y.
Metallizing Engineering Co., Inc., 1101 Prospect Ave., Westbury, N. Y.
Metallo Gasket Co., 12 Bethany St., New Brunswick, N. J.
Metal Traders, Inc., 67 Wall St., New York.
Metals Disintegrating Co., Inc., Pulverizing Machinery Div., Chatham Rd., Summit, N. J.
Metron Instrument Co., 432 Lincoln St., Denver, Colo.
Metropolitan Device Corp., 1250 Atlantic Ave., Brooklyn 16, N. Y.
Metropolitan Electric Mfg. Co., 22-50 Steinway St., Long Island City, N. Y.
Metrotex, Inc., Bayway Terminal, Elizabeth 2, N. J.
Mexico Refractories Co., Mexico, Mo.
Meyers Safety Switch Co., 419 Tehama St., San Francisco 3, Calif.
Mica Insulator Co., Schenectady 1, N. Y.
Michigan Pipe Co., The, 6581 Mill St., Gage Town, Mich.
Michigan Power Shovel Co., Benton Harbor, Mich.
Michigan Smelting & Refining Div., Bohn Aluminum & Brass Corp., 7885 Jos. Campau Ave., Detroit 26, Mich.
Michigan Steel Casting Co., Foot of St. Aubin Ave., Detroit 7, Mich.
Michigan Wire Cloth Co., 2100 Howard St., Detroit 16, Mich.
Midvale Co., 4301 Wissahickon Ave., Philadelphia 40, Pa.
Mid-West Abrasive Co., Owosso, Mich.
Midwest Carbide Corp., Empire State Bldg., New York 1, N. Y.
Midwest Electronic Laboratories, Inc., 636 Keeline Bldg., Omaha, Nebr.
Midwest Piping & Supply Co., 1450 S. Second St., St. Louis 4, Mo.
Midwestern Geophysical Laboratory, 3400 So. Harvard Ave., Tulsa, Okla.
Miehle Printing Press & Mfg. Co., Star-Kimble Motor Div., 200 Bloomfield Ave., Bloomfield, N. J.
Mill & Mine Supply, Inc., 2700—4th Ave., S., Seattle 4, Wash.
Miller, Arnold H., 120 Broadway, New York 5, N. Y.
Miller Co., 101 Center St., Meriden, Conn.
Miller Electric Mfg. Co., Box 798, Appleton, Wis.
Miller Equipment Co., Inc., 12th & New Sts., Franklin, Pa.
Miller Mfg. Co., Mills Bldg., El Paso, Tex.
Mills Corp., Elmer E., 2930 N. Ashland Ave., Chicago, Ill.
Mills Iron Works, Inc., 929 N. Main St., Los Angeles, Calif.
Milwaukee Electric Tool Corp., 5316 W. State St., Milwaukee 8, Wis.
Mine & Smelter Supply Co., Marcy Mill Div., P. O. Box 5270-Terminal Annex, Denver 17, Colo. ADV. p 112, 113
Mine Safety Appliance Co., 201 North Braddock Ave., Pittsburgh 8, Pa. ADV. p 159
Minerais et Metaux, 55 Rue D'Amsterdam, Paris 8, France
Minerals Engineering Co., 801—4th Ave., Grand Junction, Colo.
Minerals Engineering Co., 417 S. Hill St., Los Angeles 13, Calif.
Minerals Exploration & Research Corp., 2120 Ford St., Golden, Colo.
Minerals Laboratory, 1303 Grant St., Silver City, New Mexico
Minerals, Unlimited, 1724 University Ave., Berkeley, Calif.
Minerec Corp., 120 Broadway, New York, N. Y.
Miners Foundry & Mfg. Co., 200 Spring St., Nevada City, Calif.
Miner's Hardware Supply, 523 Brushton Ave., Pittsburgh 21, Pa. ADV. p 224
Mining Machine Parts, Inc., 5702 St. Clair Ave., Cleveland 8, Ohio
Minneapolis-Honeywell Regulator Co., 2954 4th Ave., So., Minneapolis 8, Minn.
Brown Instrument Div., Minneapolis-Honeywell Regulator Co., 4494 Wayne Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.
Minneapolis-Moline Co., Minneapolis 1, Minn.
Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul 6, Minn.
Minnesota Mining & Mfg. Co., Irvington Varnish & Insulator Div., 6 Argyle Terrace, Irvington 11, N. J.
Mission Mfg. Co., P.O. Box 4209, Houston, Tex.
Missouri Belting Co., 1029 S. Grand Blvd., St. Louis 4, Mo.
Mitchell Mfg. Co., 101 Sherman Ave., New York 34, N. Y.
Mitchell-Rand Insulation Co., 51 Murray St., New York 7, N. Y.
Mobile Drilling, Inc., 960 N. Pennsylvania St., Indianapolis 4, Ind.
Modern Valve-Bag Co., Allentown, Pa.
Moloney Electric Co., 5390 Bircher Blvd., St. Louis 20, Mo.
Monsanto Chemical Co., 1700 S. 2nd St., St. Louis 4, Mo.
Montgomery Belting & Leather Co., 70 S. Canal St., Akron 8, Ohio
Moore Drop Forging Co., 38 Walter St., Springfield 7, Mass.
Moore & Siegal, Shullsburg, Wis.
Moore & White Co., 15th & Lehigh Ave., Philadelphia 32, Pa.
Moore Co., The, Box 149, St. Louis 5, Mo.
Moore Co., The, 1036 Quarrier St., Charleston, West Virginia.
Morganite Brush Co., 33-02—48th Ave., Long Island City 1, N. Y.
Morris Machine Works, Baldwinsville, N. Y.
Morrison Machine Co., 1225 Madison Ave., Paterson 3, N. J.
Morse Bros. Machinery Co., P. O. Box 1708, Denver 1, Colo. ADV. p 223
Morse Chain Co., 7601 Central Ave., Detroit 10, Mich.
Morton Salt Co., 120 S. LaSalle St., Chicago 3, Ill.
Mosebach Electric & Supply Co., 1115 Arlington Ave., Pittsburgh 3, Pa.
Motor Generator Corp., Troy, Ohio
Motorola Communications & Electronics, Inc., 4501 Augusta Blvd., Chicago 51, Ill.
Mott Core Drilling Co., 830 Eighth Ave., Huntington 17, W. Va.
M-R-S Mfg. Co., P. O. Box 1206, Jackson, Miss.
Mt. Vernon-Woodberry Mills, Inc., Mercantile Trust Bldg., Baltimore 2, Md.
Mueller Brass Co., 1925 Lapeer Ave., Port Huron, Mich.
Muller & Co., Inc., Wm. H., 122 E. 42nd St., New York, N. Y.
Mullite Refractories Co., Canal St., Shelton, Conn.
Multi Electrical Mfg. Co., 4243 W. Lake St., Chicago 24, Ill.
Murphy Diesel Co., 5317 W. Burnham St., Milwaukee 11, Wis.
Murphy, F. M., 1201 Maryland Parkway, Las Vegas, Nev.
Murray Iron Works Co., 1106 Washington St., Burlington, Iowa
Myers-Whaley Co., Inc., P. O. Box 789 Knoxville 1, Tenn.

N

Nachod & U. S. Signal Co., 4777 Louisville Ave., Louisville 9, Ky.
Nagle Pumps, Inc., 1249 Center St., Chicago Heights, Ill. ADV. p 206
Nash Engineering Co., 218 Wilson Rd., South Norwalk, Conn.
Nathan Mfg. Co., 416 E. 106th St., New York, N. Y.
National Automotive Fibres, Inc., Railroad Ave., & Kennedy St., Oakland, Calif.
National Cylinder Gas Co., 840 N. Michigan Ave., Chicago 11, Ill.
National Cylinder Gas Co., Tube Turns Div., 224 East Broadway, Louisville 1, Ky.
National Electric Coil Co., 794 Chambers Rd., Columbus, Ohio
National Electric Products Corp., Gateway Center, 140 Stanwix St., Pittsburgh 22, Pa.
National Enameling & Mfg. Co., 61 Bridge St., Philadelphia, Pa.
National Filter Media Corp., 1717 Dixwell Ave., New Haven 11, Conn.
National Fuse & Powder Co., 3801 Delganv St., Denver 5, Colo.
National Iron Co., Ramsey St. & 50th Ave. W., Duluth 7, Minn. ADV. p 167
National Lead Co., 111 Broadway, New York 6, N. Y.
National Malleable & Steel Castings Co., 10606 Quincy Ave., Cleveland 6, Ohio. ADV. Fourth Cover
National Mine Service Co., P. O. Box 32, Beckley, W. Va.
National Powder Co., Eldred, Pa.
National Production Co., 4561 St. Jean Ave., Detroit 13, Mich.
National Screw Mfg. Co., Chester Hoist Div., Lisbon, Ohio
National Supply Co., Two Gateway Center, Pittsburgh, Pa.
National Supply Co., 1401 Sheridan Ave., Springfield, Ohio
National Tank & Pipe Co., 2301 N. Columbia Blvd., Portland 3, Ore.
National Technical Laboratories, 820 S. Mission St., South Pasadena, Calif.
National Transmission Products, Inc., 684 Broadway, New York, N. Y.
National Tube Co., Frick Bldg., Pittsburgh 30, Pa.
National Vulcanized Fibre Co., Wilmington, Del.
Naylor Pipe Co., 1243 E. 92nd St., Chicago 19, Ill. ADV. p 174
Neal Machinery Co., H. T., 57 Post St., San Francisco, Calif. ADV. p 222
Neff & Fry Co., Camden, Ohio
Nelson Electric Manufacturing Co., 217-A N. Detroit St., Tulsa, Okla.
Newage International, Inc., 231-35 E. 42nd St., New York 17, N. Y.
Newark Wire Cloth Co., 370 Verona Ave., Newark 4, N. J.
Newcomer Products, Inc., Latrobe, Pa.
New Era Engineering Co., 458 West 29 St., Chicago 16, Ill.
Newhall Chain Forge & Iron Co., 48 W. Broadway, New York 7, N. Y.
New Jersey Meter Co., Plainfield, N. J.
New Jersey Zinc Co., 160 Front St., New York 7, N. Y.
Newman-Stern Co., Newman-Stern Bldg., East 12th St., Cleveland 14, Ohio
New Mexico Minerals Laboratory, 1303 Grant St., Silver City, N. M.
Newport Industries, Inc., 230 Park Ave., New York, N. Y.
New World Exploration, Res. & Dev. Corp., 6547 Aqueduct Ave., Van Nuys, Calif.
New York Air Brake Co., 422 Lexington Ave., New York, N. Y.
New York Air Brake Co., Aurora Pump Div., 86 Loucks St., Aurora, Ill. ADV. p 210
New York Air Brake Co., Hydraulic Div., 230 Park Ave., New York 17, N. Y.
New York Belting & Packing Co., 1 Market St., Passaic, N. J.
New York Engineering Co., 75 West St., New York, N. Y.
New York & New Jersey Lubricant Co., 292 Madison Ave., New York 17, N. Y.
New York Rubber Corp., 100 Park Ave., New York 17, N. Y.
Nice Ball Bearing Co., 30th & Hunting Park Ave., Philadelphia 40, Pa.
Nichols Engineering & Research Corp., 70 Pine St., New York 5, N. Y.
Nicholson Co., Inc., 10 Rockefeller Plaza, New York 20, N. Y.
Nicholson & Co., W. H., 12 Oregon St., Wilkes-Barre, Pa.
Nielsen Blue Print, Inc., 108 N. 3rd St., Grand Junction, Colo.
Nolan Co., 120 Pennsylvania St., Bowerston, Ohio
Noma Electric Corp., Ansonia Electrical Div., Ansonia, Conn.
Nordberg Mfg. Co., 3073 S. Chase Ave., Milwaukee 1, Wis. ADV. p 110
Norgren Co., C. A., 3401 S. Elati St., Englewood, Colo.
Norma-Hoffman Bearings Corp., Stamford, Conn.
North American Mfg. Co., 2910 E. 75th St., Cleveland 4, Ohio
North American Phillips Co., 100 E. 42nd St., New York 17, N. Y.
North American Refractories Co., E. 6th at Euclid Ave., Cleveland 14, Ohio

Northeastern Co., 238 Main St., Cambridge 42, Mass.
Northern Blower Co., 6409 Barberton Ave., Cleveland, Ohio. ADV. p 189
Northern Conveyor Co., P. O. Box 46, Janesville, Wis.
Northern Engineering Works, 2618 Atwater St., Detroit 7, Mich.
Northwest Engineering Co., 135 S. LaSalle St., Chicago 3, Ill.
Northwest Steel Rolling Mills, 4315—9th Ave., N.W., Seattle 7, Wash.
Northwestern Electric Co., 1750 N. Springfield Ave., Chicago 47, Ill.
Norton Co., 1 New Bond St., Worcester 6, Mass.
Norwalk Co., Water St., South Norwalk, Conn.
Novo Engine Co., 702 Porter St., Lansing 5, Mich.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago, Ill. ADV. p 209
Nuclear Research Corp., 2563 Grays Ferry Ave., Philadelphia 46, Pa.
Nucleonic Corp. of America, 499 Union St., Brooklyn 31, N. Y.

O

Ohio Brass Co., Mansfield, Ohio
Ohio Carbon Co., 12508 Berea Rd., Cleveland 11, Ohio
Ohio Electric Mfg. Co., 5900 Maurice Ave., Cleveland 27, Ohio
Ohio Forge & Machine Corp., 3010 Woodhill Rd., Cleveland 4, Ohio
Ohio Gear Co., 1333 E. 179th St., Cleveland 10, Ohio
Ohio Grease Co., 525 N. Spring St., Loudonville, Ohio
Ohio Injector Co., 275 Main St., Wadsworth, Ohio
Ohio Locomotive Crane Co., 1816 Southern Ave., Bucyrus, Ohio
Ohio Oil Co., Findlay, Ohio
Oil City Boiler Works, Oil City, Pa.
Oilgear Co., The, 1560 W. Pierce St., Milwaukee 4, Wis.
Oil Well Supply Co., Petrolia, Ontario, Canada.
Oil Well Supply Co., Witte Engine Works Div., 16th & Oakland, Kansas City 3, Mo.
Okadee Co., 332 S. Michigan Ave., Chicago 4, Ill.
The Okonite Co., Passaic, N. J.
Okonite Co., Hazard Insulated Wire Works Div., 72 Hazle St., Wilkes-Barre, Pa.
Olds Alloy Co., 4481 Mason St., South Gate, Calif.
Olin-Mathieson Chemical, East Alton, Ill.
Olin-Mathieson Chemical, Bond Electric Corp. Div., East Alton, Ill.
Oliver Corp., 400 West Madison, Chicago 6, Ill.
Oliver Corp., The, A. B. Farquhar Div., 142 N. Duke St., York, Pa.
Oliver Iron & Steel Corp., S. 10th & Muriel Sts., Pittsburgh 3, Pa.
Omaha Scientific Supply Corp., 3623 Lake St., Box 1706, Omaha 4, Nebr.
Omega Machine Co., 345 Harris Ave., Providence 1, R. I.
Onan & Sons, Inc., D. W., University Ave., S.E., at 25th, Minneapolis 14, Minn.
Onox, Inc., 121 Second St., San Francisco 5, Calif.
Orange Roller Bearing Co., Inc., 557 Main St., Orange, N. J.
Ore & Chemical Corp., 80 Broad St., New York, N. Y.
Oronite Chemical Co., 38 Sansome St., San Francisco, Calif.
Orton Crane & Shovel Co., 608 S. Dearborn St., Chicago 5, Ill.
Osgood-General, P. O. Box 515, Marion, Ohio
Oshkosh Motor Truck, Inc., Oshkosh, Wis.
Osmose Wood Preserving Co., 980 Ellicott St., Buffalo 9, N. Y.
Ottumwa Box Car Loader Co., Ottumwa, Iowa
Overseas Raw Materials Corp., 11 Broadway, New York, N. Y.
Overstrom & Sons, 2213 West Mission Rd., Alhambra, Calif.
Owatonna Tool Co., 353 Cedar St., Owatonna, Minn.
Owen Bucket Co., 6001 Breakwater Ave., Cleveland 2, Ohio
Owens-Corning Fiberglas Corp., 1833 Nicholas Bldg., Toledo 1, Ohio
O. Z. Electrical Mfg. Co., 262 Bond St., Brooklyn 2, N. Y.

P

Pacific Car & Foundry Co., Renton, Wash.
Pacific Coast Engineering Co., Oak & Cement Sts., Alameda 6, Calif.
Pacific Electric Mfg. Corp., 5815—3rd St., San Francisco 24, Calif.
Pacific Foundry Co., 3100—19th St., San Francisco 10, Calif.
Pacific Gear & Tool Works, Inc., 1035 Folsom St., San Francisco 3, Calif.
Pacific Lumber Co., 100 Bush St., San Francisco, Calif.
Pacific Pipe Co., 403 Folsom St., San Francisco 5, Calif.
Pacific Steel Foundry Co., 1979 N. W. Vaughn, Portland 9, Ore.
Pacific Wire Rope Co., 1840 E. 15th St., Los Angeles, Calif.
Pacific Wood Tank Corp., 461 Market St., San Francisco 5, Calif.
Page Belting Co., Concord, N. H.
Page Engineering Co., Clearing Post Office, Chicago 38, Ill.
Palmer-Bee Co., 1701 Poland Ave., Detroit 12, Mich.
Palnut Co., The, 61 Cordier St., Irvington, N. J.
Pan-Am Southern Corp., New Orleans, La.
Pangborn Corp., 630 Pangborn Blvd., Hagerstown, Md.
Paraffine Companies, Inc., 475 Brannan St., San Francisco 19, Calif.
Paragon-Revolute Corp., 97 South Ave., Rochester 4, N. Y.
Paris Mfg. Co., Paris, Ill.
Parker Electrical Mfg. Co., 221 Washington St., Oakland 7, Calif.
Parker Safety Equipment Co., 785 Lyons Ave., Irvington 11, N. J.
Parsons Co., Ralph M., 617 So. Olive St., Los Angeles, Calif.
Parsons Engineering Corp., 2545 E. 79th St., Cleveland 4, Ohio
Patrick, Inc., R. S., Sellwood Bldg., Duluth 2, Minn.
Patrick & Wilkins Co., 51 No. 7th St., Philadelphia 6, Pa.
Patterson Foundry & Machine Co., 41 Helene St., East Liverpool, Ohio
Patton Mfg. Co., Inc., West Pleasant & Thomas Sts., Springfield, Ohio
Paulsen-Webber Cordage Corp., 170 John St., New York, N. Y.
Pease Co., C. F., 2601 W. Irving Park Rd., Chicago, Ill.
Peck & Harvey Co., 5650 North Western Ave., Chicago 45, Ill.
Peerless Electric Co., The, 1401 W. Market St., Warren, Ohio
Peerless Machine Co., 1600 Junction Ave., Racine, Wis.
Peerless Photo Products, Inc., Shoreham, N. Y.
Penberthy Injector Co., 1242 Holden Ave., Detroit 2, Mich.
Pence & Co., Inc., Earl H., 2150 Washington Ave., San Leandro, Calif.
Pendleton Woolen Mills, Washougal, Wash.
Peninsular Grinding Wheel Co., 729 Meldrum Ave., Detroit 7, Mich.
Penn Machine Co., 106 Station St., Johnstown, Pa.
Penn Mfg. & Supply Co., 45 Westminster St., Wilkes-Barre, Pa.
Penna. Pump & Compressor Co., Easton, Pa.
Pennsylvania Drilling Co., 1201 Chartiers Ave., Pittsburgh 20, Pa.
Pennsylvania Transformer Co., 808 Ridge Ave., Pittsburgh 12, Pa.
Peoria Malleable Castings Co., Foot of Alexander St., Peoria 1, Ill.
Perkin Engineering Co., El Segundo, Calif.
Perkins Machine & Gear Co., West Springfield, Mass.
Permagile Corp. of America, 32-14 Northern Blvd., Long Island City 1, N. Y.
Permold Co., 800 W. Liberty St., Medina, Ohio
Permutit Co., 330 W. 42nd St., New York 36, N. Y.
Peterson Filters & Engr. Co., 137 Motor Ave., Salt Lake City 1, Utah
Pettibone Mulliken Corp., 4710 W. Division St., Chicago 51, Ill.
Pettinos, Inc., George F., 1206 Locust St., Philadelphia 7, Pa.
Phelps Dodge Copper Products Corp., Habirshaw Cable & Wire Div., 40 Wall St., New York 5, N. Y.
Phelps Dodge Refining Corp., 40 Wall St., New York 5, N. Y.
Philadelphia Belting Co., 6th & Spring Garden Sts., Philadelphia 23, Pa.
Philadelphia Gear Works, G St. & Erie Ave., Philadelphia 34, Pa.
Philadelphia Quartz Co., 1146 Public Ledger Bldg., Philadelphia 6, Pa.
Philadelphia Steel & Iron Co., Conshohocken, Pa.
Phillip Bros., Inc., 70 Pine St., New York 5, N. Y.
Phillips Corp., Arch St., Carnegie, Pa.
Phillips Mine & Mill Supply Co., Jane & Phillips Sts., Pittsburgh, Pa.
Phillips Petroleum Co., Bartlesville, Okla.
Phoenix Metal Products Co., 4715 N. 27th St., Milwaukee, Wis.
Phosphor Bronze Corp., 20 Franklin St., Seymour, Conn.
Photographic Survey Corp., Ltd., Toronto.
Pioneer Alloy Products Co., 16611 Euclid Ave., Cleveland 12, Ohio
Pioneer Engineering Works, Inc., 1515 Central Ave., Minneapolis 13, Minn. ADV. p 198, 199
Pioneer Rubber Mills, 345 Sacramento St., San Francisco 11, Calif.
Pitkin, Inc., Lucius, 47 Fulton St., New York 7, N. Y.
Pitman Manufacturing Co., 300 West 79 Terrace, Kansas City 2, Mo.
Pittsburgh Coal Washer Co., Duss Ave., Ambridge, Pa.
Pittsburgh-Des Moines Steel Co., Neville Island, Pittsburgh 25, Pa.
Pittsburgh Electrical & Machine Works, 123 Barker Pl., Pittsburgh 22, Pa.
Pittsburgh Gear Co., 27th & Smallman Sts., Pittsburgh 22, Pa.
Pittsburgh Knife & Forge Co., 1421 Reedsdale St., Pittsburgh 12, Pa.
Pittsburgh Lectromelt Furnace Corp., Foot of 32nd St., Pittsburgh, Pa.
Pittsburgh Plate Glass Co., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Reflector Co., Oliver Bldg., Pittsburgh 22, Pa.
Pittsburgh Screw & Bolt Corp., P. O. Box 1708 Pittsburgh 30, Pa.
Pittsburgh Standard Conduit Co., Etna, Pa.
Plasteel Products Corp., 15 McAdam Ave., Washington, Pa.
Plastex Pipe & Extrusion Co., 402 Mt. Vernon Ave., Columbus 3, Ohio
Platt Iron Works, 435 Keowee St., Dayton 1, Ohio
Plibrico Jointless Firebrick Co., 1800 Kingsbury St., Chicago 14, Ill.
Plummer Mfg. Co., W. A., 752 S. San Pedro St., Los Angeles 14, Calif.
Pollock Co., William B., 101 Andrews Ave., Youngstown, Ohio
Poole Foundry & Machine Co., 1700 Union Ave., Baltimore 11, Md.
Porter-Cable Machine Co., 1714 N. Salina St., Syracuse 8, N. Y.
H. K. Porter Co., Laclede-Christy Co. Div., 2000 Hampton Ave., St. Louis 10, Mo.
Porter Co., H. K., Leschen Wire Rope Div., 2727 Hamilton Ave., St. Louis 12, Mo.
Porter Co., H. K., Quaker Rubber Co., Div., Tacony & Comly Sts., Philadelphia 24.
Portland Woolen Mills, Inc., Industrial Fabrics Div., 6639 N. Baltimore Ave., P. O. Box 2620 Portland 3, Ore.
Portman Sewing Machine Co., 70 Portman Rd., New Rochelle, N. Y.
Porto-Pump, Inc., 227 Iron St., Detroit.
Posey Iron Works, Inc., 560 Prince St., Lancaster, Pa.
Post Co., Frederick, 3650 N. Avondale Ave., Chicago 18, Ill.
Post-Glover Electric Co., 221 W. 3rd St., Cincinnati 2, Ohio
Powell Co., Wm., The, 2525 Spring Grove Ave., Cincinnati 22, Ohio
Powell Valves, 2525 Spring Grove Ave., Cincinnati 22, Ohio
Powercraft Corp., 2215 DeKalb St., St. Louis 4, Mo.
Powerlite Switchboard Co., 4145 E. 79th St., Cleveland 5, Ohio
Power Plants, Inc., 1755 W. 33rd St., Cleveland 14, Ohio
Prat-Daniel Corp., Port Chester, N. Y.
Precision Chain Co., Terre Haute, Indiana
Precision Grinding Wheel Co., 8301 Torresdale Ave., Philadelphia 36, Pa.

Precision Radiation Instruments, Inc., 2235 S. La Brea St., Los Angeles 16, Calif. ADV. p 185
Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.
Prescott Co., Menominee, Mich.
Pressed Steel Car Co., 25 Broad St., New York 4, N. Y.
Prest-O-Lite Battery Co., Toledo 1, Ohio
Prime Mover Co., Muscatine, Iowa
Prins & Associates, K., Box 46, Wellston, Ohio
Process Engineering, Inc., 624 Somerville Ave., Somerville, Mass.
Production Equipment Corp., 2926 W. Lake St., Chicago 12, Ill.
Productive Equipment Corp., 2926 W. Lake St., Chicago 12, Ill.
Provo Foundry & Machine Co., 388 E. 9th So., Provo, Utah
Frank Prox Co., Terre Haute, Indiana
Pullman-Standard Car Mfg. Co., 79 E. Adams St., Chicago 3, Ill.
Pulmosan Safety Equipment Corp., 644 Pacific St., Brooklyn, N. Y.
Pulva Corp., 550 Hight St., Perth Amboy, N. J.
Punch-Lok Co., 321 North Justine St., Chicago 7, Ill.
Pure Carbon Co., 441 Hall Ave., St. Marys, Pa.
Pure Oil Co., 35 E. Wacker Drive, Chicago 1, Ill.
Pyle-National Co., 1335 N. Kostner Ave., Chicago 51, Ill.
Pyott Foundry & Machinery Co., 328 N. Sangamon St., Chicago 7, Ill.
Pyramid Grate Corp., 101 Park Ave., New York, N. Y.

Q

Quaker City Gear Works, 1932 N. Front St., Philadelphia, Pa.
Quaker Pioneer Rubber Mills, 520—4th St., San Francisco 7, Calif.
Queen City Machine Tool Co., 217 E. Second St., Cincinnati 2, Ohio
Quick Charge, Inc., 1750 N.E. 10th St., Oklahoma City, Okla.
Quick-Seal Products, Inc., Herndon, Pa.
Quick-Way Truck Shovel Co., 2401 E. 40th Ave., Denver, Colo.
Quigley Co., 527 Fifth Ave., New York 17, N. Y.

R

Racine Steel Castings Co., 1442 Forest St., Racine, Wis.
Radiac Company, Inc., The, 489 Fifth Ave., New York 17, N. Y.
Radiation Counter Laboratories, 1844 W. 21st St., Chicago 8, Ill.
Radio Corp. of America, Engrg. Prod. Div., Bldg. 15-1, Camden 2, N. J.
Radio Specialists Co., 417 W. 12th Ave., Denver 4, Colo.
Rahmann & Co., George, 31 Spruce St., New York 7, N. Y.
Railway & Industrial Equipment Div., I-T-E Circuit Breaker Co., Greensburg, Pa.
Railway Track-Work Co., 3207 Kensington Ave., Philadelphia, Pa.
Ralco Mfg. Co., 141 N. Albany Ave., Chicago, Ill.
Ramsey Chain Co., 1033 Broadway, Albany 1, N. Y.
Raniville Co., F., 241 Pearl St., N.W., Grand Rapids 2, Mich.
Rattan Mfg. Co., 550 State St., New Haven 7, Conn.
Rawlplug Co., 271 Church St., New York, N. Y.
Rawson Electrical Instrument Co., 102 Potter St., Cambridge 42, Mass.
Raybestos-Manhattan, Inc., Passaic, N. J. ADV. p 138
Raybestos-Manhattan, Inc., Manhattan Rubber Div., 42 Townsend St., Passaic, N.J. ADV. p 138
Raymond Bag Co., Middleton, Ohio
Ray-O-Vac Co., 212 E. Washington Ave., Madison 10, Wis.
Raytheon Mfg. Co., 5921 W. Dickens St., Chicago 39, Ill.
R. C. A. Engineering Products, Camden, N. J.
Reading Crane & Hoist Corp., Box 1139, Reading, Pa.
Ready Power Co., 11231 Freud Ave., Detroit, Mich.
Realty & Industrial Corp., Elpeco Div., 1000 8th Ave., Bethlehem, Pa.
Realty & Industrial Corp., Roller-Smith Div., 1768 W. Market St., Bethlehem, Pa.
Recoveries, Inc., 2614 N. E. 25th Ave., Portland 12, Ore.
Reed Roller Bit Co., Box 2119, Houston 1, Tex.
Reed Standard Corp., York, Pa.
Reeves Pulley Co., 1225—7th St., Columbus, Ind.
Reich Bros. Mfg. Co., 1439 Ash St., Terre Haute, Ind. ADV. p 192
Reilly Tar & Chemical Corp., Merchants Bank Bldg., Indianapolis 4, Ind.
Reintjes Co., George P., 2519 Jefferson St., Kansas City 6, Mo.
Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio
Reliance Instrument Co., 3938 W. Roosevelt Rd., Chicago, Ill.
Reliance Steel Casting Co., 2818 Smallman Ave., Pittsburgh 22, Pa.
Remaly Mfg. Co., Cedar St., Tamaqua, Pa.
Remington Arms Co., Inc., Barnum Ave., Bridgeport, Conn. ADV. p 197
Remington Rand Inc., 315 Fourth Ave., New York 10, N. Y.
Reo Motors, Inc., Lansing, Mich.
Republic Creosoting Co., Merchants Bank Bldg., Indianapolis 6, Ind.
Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago 47, Ill.
Republic Flue Cement Co., Salt Lake City, Utah
Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio
Republic Steel Corp., Berger Mfg. Div., 1038 Belden Ave., N.E., Canton 5, Ohio
Republic Steel Corp., Truscon Steel Div., Albert St., Youngstown 1, Ohio
Republic Steel Corp., Union Drawn Steel Div., Harsh Ave., S.E., Massillon, Ohio
Research-Cottrell, Inc., Bound Brook, N. J. ADV. p 184
Resisto-Loy Co., 127 Baylis St., S.W., Grand Rapids 7, Mich.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.
Revere Electric Mfg. Co., 6017 Broadway, Chicago 40, Ill.
Reynolds Metals Co., 2500 S. 3rd St., Louisville 1, Ky.
Rhoads & Son, J. E., 35 N. 6th St., Philadelphia 6, Pa.
Riblet Tramway Co., 1231 N. Washington St., Spokane, Wash. ADV. p 184
Rice Pump & Machine Co., Belgium, Wis.
Richardson Scale Co., Clifton, N. J.
Richards-Wilcox Mfg. Co., 1176—3rd St., Aurora, Ill.
Ridge Equipment Co., Fallentimber, Pa.
Riegel Textile Corp., 260 Madison Ave., New York, N. Y.
Rife Hydraulic Engine Mfg. Co., 30 Church St., New York 7, N. Y.
Ritter Products Corp., Ritter Park, Rochester 3, N. Y.
Robbins & Myers, Inc., 1345 Lagonda Ave., Springfield, Ohio
Robertson Co., H. H., Farmers Bank Bldg., Pittsburgh 22, Pa.
Robinson Air-Activated Conveyor Systems, 205 E. 42nd St., New York 17, N. Y.
Robinson & Robinson, Union Building, Charleston, W. Va.
Robinson Ventilating Co., Zelienople, Pa.
Rochester Ropes, Inc., Culpepper, Va.
Rockbestos Products Corp., Nicoll & Cannel Sts., New Haven 4, Conn.
Rockford Bolt & Steel Co., 126 Mill St., Rockford, Ill.
Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.
Rockwell Spring & Axle Co., The Timken-Detroit Axle Div., 100 Clark St., Detroit, Mich.
Rockwood Pulley Mfg. Co., Inc., 29 Crosby St., New York 13, N. Y.
Rocky Mountain Instrument Co., 1410—16th St., Denver, Colo.
Rogers Brothers Corp., Albion, Pa.
Rogers Iron Works Co., Joplin, Mo. ADV. p 203
Rohm & Haas Co., 712 Locust St., Phila.
Roller Bearing Co. of America, Whitehead Road, Trenton, N. J.
Rollway Bearing Co., Inc., 541 Seymour St., Syracuse 4, N. Y.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Root Co., B. M., York, Pa.
Root & Simpson, Inc., 1306 E. 17th Ave., Denver 1, Colo.
Rose Mfg. Co., 2700 W. Barberry Place, Denver 4, Colo.
Ross Screen & Feeder Co., 100 Quimby St., Westfield, N.J. ADV. p 163
Roto-Flow Screen Co., 249 N. Water St., Milwaukee, Wis.
Rotron Mfg. Co., 7 Schoonmaker Lane, Woodstock, N. Y.
Round Chain Co.'s. Broadway & Chaincraft Rd., Cleveland 5, Ohio
Round & Son, Inc., David, P. O. Box 883, Cleveland 22, Ohio
Round Woodhouse Chain & Mfg. Co., 251 3rd St., Trenton, N. J.
Rowan Controller Co., 2313 Homewood Ave., Baltimore 18, Md.
Royal Electric Mfg. Co., 621 E. 40th St., Chicago 15, Ill.
Ruberoid Co., 500 Fifth Ave., New York.
Rubicon Co., 3751 Ridge Ave., Philadelphia.
Russell-Ritter Amalgamator Co., University Station, Seattle, Wash.
Russell & Stoll Co., 125 Barclay St., N. Y.
Rust Furnace Co., 575 Sixth Ave., Pittsburgh 19, Pa.
Rust-Oleum Corp., 2425 Oakton St., Evanston, Ill.
Ruth Co., 1437 Blake St., Denver 2, Colo.
Ryerson & Son, Inc., Joseph T., 16th & Rockwell Sts., P. O. Box 8000A, Chicago 80.

S

S & C Electric Co., 4435 Ravenswood Ave., Chicago 40, Ill.
S & M Lamp Co., 119 W. 36th Pl., Los Angeles 54, Calif.
Sadtler & Son, Inc., Samuel P., 310 S. 13th St., Philadelphia, Pa.
Safety Belt Lacer Co., 5332 N. Menard Ave., Chicago 30, Ill.
Safety Clothing & Equipment Co., 7016 Euclid Ave., Cleveland 3, Ohio
Safety First Shoe Co., Holliston, Mass.
Safety First Supply Co., 425 Magee St., Pittsburgh 19, Pa.
Sahara Oil Co., 15 E. Main St., DuQuoin, Ill.
Salem Tool Co., Salem, Ohio. ADV. p 170
Samuels & Co., Inc., Frank, Lincoln Liberty Bldg., Philadelphia 7, Pa.
Sanderson Cyclone Drill Co., 157 S. Main St., Orville, Ohio
Sanford-Day Iron Works, Inc., Dale Ave., P. O. Box 1511, Knoxville 9, Tenn.
Sanford-Day Iron Works, Brown-Fayro Div., 1937 Brown St., Johnstown, Pa.
Sangamo Electric Co., Springfield, Ill.
Santa Fe Tank & Tower Co., 5401 S. Boyle Ave., Los Angeles 11, Calif.
Sarco Co., Inc., 350 Fifth Ave., New York.
Sauereisen Cements Co., 1242 Sharpsburg St., Pittsburgh 15, Pa.
Sauerman Bros., Inc., 626 S. 28th Ave., Bellwood, Ill.
Savage Co., W. J., 912 W. Clinch Ave., Knoxville 2, Tenn.
Sawyer Bailey Corp., 1559 Niagara St., Buffalo 13, N. Y.
Sawyer Belt Hook Co., 16 Warren Ave., Pawtucket, R. I.
Saylor Electric Products Corp., 1014 Lynn St., Detroit 11, Mich.
Scandinavia Belting Co., 248 Central Ave., Newark 1, N. J.
Schaffer Poidometer Co., 2828 Smallman St., Pittsburgh 22, Pa. ADV. p 180
Schaible Co., The, 1016 Summer St., Cincinnati 2, Ohio
Schatz Mfg. Co., The, Poughkeepsie, N. Y.
Schield Bantam Co., 221 Park St., Waverly, Iowa
Schieren Co., Chas. A., 30 Ferry St., New York 38, N. Y.
Schneible Co., Claude B., 2827—25th St., Detroit 16, Mich.
Schneider Mfg. Corp., 315 N. Franklin St., Muncie, Ind.,
Schonrock Equipment Mfg. Co., San Angelo, Tex.
Schramm, Inc., West Chester, Pa. ADV. p 187
Schroeder Brothers, 3116 Penn Ave., Pittsburgh 1, Pa.
Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia 22, Pa.
Schutz-O'Neill Co., 317 Portland Ave., Minneapolis 15, Minn.
Schwartz Belting Co., 74 Murray St., N. Y.

Scott, Walter J., 320 S.W. Broadway, Portland, Ore.
Scranton Electric Construction Co., Scranton.
Screen Equipment Co., Inc., Buffalo 25, N. Y.
Security Locknut Corp., 1800 15th Ave., Melrose Park, Ill.
Seeger Refrigerator Co., 850 Arcade St., St. Paul 6, Minn.
Seiberling Rubber Co., Barberton St., Akron.
Seismograph Service Corp., P. O. Box 1590, Tulsa 1, Okla.
Sellstrom Mfg. Co., 615 N. Aberdeen St., Chicago 22, Ill.
Service Diamond Tool Co., Radioactivity Instrument Division, 2505 Burdette Ave., Ferndale 20, Mich.
Service Supply Corp., 20th & Erie Ave., Philadelphia 32, Pa.
Seymour Mfg. Co., 39 Franklin St., Seymour, Conn.
Sharp Instruments, Ltd., Toronto, Canada
Sharples Chemicals, Inc., 1100 Widener Bldg., Philadelphia 7, Pa.
Shaw Blue Print Machine Co., 12 E. Park, Newark, N. J.
Shawinigan Products Corp., 350 Fifth Ave., New York 1, N.Y.
Shell Oil Co., 30 Rockefeller Plaza, N. Y.
Shenango-Penn Mold Co., 1751 W. 3rd St., Dover, Ohio
Shepard Niles Crane & Hoist Corp., 406 Schuyler Ave., Montour Falls, N. Y.
Sheppard Co., Inc., R. H., Hanover, Pa.
Sherman Mfg. Co., H. B., Battle Creek, Mich.
Sherwin Instrument Co., 2875 Broadway, New York 25, N. Y.
Sherwin-Williams Co., 101 Prospect Ave., N.W., Cleveland 1, Ohio
Shippert Mfg. Co., 414 O. S. Galena Ave., Dixon, Ill.
Shrader Co., F. W., 5788 Washington Blvd., Culver City, Calif.
Shriver & Co., T., 848 Hamilton St., Harrison, N. J.
Sight Feed Generator Co., West Alexandria, Ohio
Signal Electric Mfg. Co., 1915 Broadway, Menominee, Mich.
Silka Chemical Corp., 33-47 Gregory Ave., Passaic, N. J.
Sikes Co., S. R., 1028 S. 3rd St., Minneapolis.
Silent Hoist & Crane Corp., 877—63rd St., Brooklyn 20, N. Y.
Simonds Saw & Steel Co., Fitchburg, Mass.
Simonds Saw & Steel Co., Simonds Abrasive Co. Div, Fitchburg, Mass.
Simonds Worden White Co., Dayton 7, Ohio
Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.
Simplicity Engineering Co., Durand, Mich.
Simplicity System Co., Riverside Drive, East Chattanooga, Tenn.
Sinclair Refining Co., 600 Fifth Ave., N. Y.
Singer Sewing Machine Co., 149 Broadway, New York 6, N. Y.
Sintering Machinery Corp., Netcong, N. J.
Sintering Machinery Corp., Dwight Lloyd, Inc., Div., 120 Sinter Ave., Netcong, N. J.
Sivyer Steel Casting Co., S. 43rd & Mitchell Sts., Milwaukee, Wis.
Six Wheels, Inc., 1584 E. 20th St., Los Angeles 11, Calif.
SKF Industries, Inc., P. O. Box 6731, Philadelphia 32, Pa.
Skinner Engine Co., 337 W. 12th St., Erie, Pa.
Skookum Co., 8504 N. Crawford St., Portland 3, Ore.
Slip-On, Inc., 401 Broadway, New York.
Sly Mfg. Co., W. W., 4700 Train Ave., Cleveland 2, Ohio
Smidth & Co., F. L., 11 West 42nd St., New York 36, N.Y. ADV. p 207
Smit & Co., Anton, 333 W. 52nd St., New York 19, N.Y. ADV. p 224
Smit & Sons, Inc., J. K., Murray Hill, N.J. ADV. p 176
Smith & Co., Gordon, 445 College St., Bowling Green, Ky.
Smith Co., A. O., 3533 North 27th St., Milwaukee 1, Wisc.
Smith Corp., Winfield H., Springville, N. Y.
Smith-Emery Co., 920 Santee St., Los Angeles 15, Calif.
Smith Engineering Works, 502 East Capital Dr., Milwaukee 12, Wis.
Smith Meter Products Corp., A. O., 5715 Smithway, Los Angeles, Calif.
Smith Power Transmission Co., The, 1545 E. 23rd St., Cleveland 14, Ohio.
Smith & Serrell, 31 Clinton St., Newark 2, N. J.
Smith Welding Equip. Corp., 2633 S. E. 4th St., Minneapolis 14, Minn.
Smoot-Holman Co., 321 N. Eucalyptus Ave., Inglewood, Calif.
Snap-Tite, Inc., 201 Titusville Rd., Union City, Pa.
Snell, Inc., Foster D., 29 W. 15th St., N. Y.
The Snow-Nabstedt Gear Corp., 251 Welton St., Hamden 7, Conn.
Snyder Mine & Chemical Lab., Box 234, Richland, Ore.
Snyder & Son., Inc., M. L., 1811 E. York St., Philadelphia 25, Pa.
Socony-Vacuum Oil Co., 26 Broadway, N. Y.
Sonneborn Sons, Inc., L., 300 - 4th Ave., New York 10, N. Y.
Sorel Steel Foundries, Ltd., 1405 Peel St., Montreal, Canada.
Sorgel Electric Co., 838-B W. National Ave., Milwaukee 4, Wis.
Soule Steel Co., 1750 Army St., San Francisco 24, Calif.
South Bend Air Products, Inc., 322 E. Colfax Ave., South Bend 22, Ind.
South Bend Current Controller Co., 1236 North Side Blvd., South Bend 15, Ind.
South Bend Lathe Works, 419 East Madison St., South Bend 22, Ind.
Southeastern Diamond Drilling Co., Jackson Bldg. Annex, Ashville, N. C.
Southern Battery Co., 14 Farrell St., Appomattox, Va.
Southern Carbon Brush Co., 7 - 18th St., S. W., Birmingham, Ala.
Southern Friction Materials Co., Charlotte 1, N. C.
Southern Oxygen Co., Washington 19, D. C.
Southern States Equipment Corp., 28 S. 20th St., Birmingham 3, Ala.
Southwest Welding & Mfg. Co., 3201 N. Mission Rd., Alhambra, Calif.
Southwestern Engineering Co., 4800 Santa Fe Ave., Los Angeles 58, Calif.
Southwestern Industrial Electronics Co., P. O. Box 13058, Houston 19, Texas
Southwestern Petroleum Co., Ft. Worth, Tex.
Spang & Company, 143 Etna St., Butler, Pa.
Spartan Air Services, Ltd., Ottawa, Canada.
Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn.
Specialty Engineering Co., Allegheny & Trenton Aves., Phila. 34, Pa.
Speer Carbon Co., St. Marys, Pa.
Spencer Turbine Co., 484 New Park Ave., Hartford 6, Conn.
Sperry Corp., Wheeler Insulated Wire Co., Waterbury, Conn.
Split Ballbearing Corp., 21 Mascoma St., Lebanon N. H.
SPO., Inc., 6556 Grand Division Ave., Cleveland, 25, Ohio.
Sprague & Henwood, Inc., 221 W. Olive St., Scranton, Pa. ADV. opp. p 130
Spray Engineering Co., 114 Central St., Somerville 45, Mass.
Springfield Boiler Co., 20th & E. Capitol Ave., Springfield, Ill.
Sprout, Waldron & Co., Inc., Muncy, Pa.
Square D Company, 6060 Rivard St., Detroit 11, Mich.
Stackpole Carbon Co., St. Marys, Pa.
Stahl Gear & Machine Co., 3901 Hamilton Ave., Cleveland 14, Ohio.
Stainless Welded Products, Inc., 251 Cornelison Ave., Jersey City 2, N. J.
Stamler Co., W. R., P.O. Box 79, Paris, Ky. ADV. p 172
Standard Carbon Co., 324 N. 7th St., Steubenville, Ohio.
Standard Electrical Tool Co., 2488 River Rd., Cincinnati 4, Ohio
Standard Electric Equipment Corp., 100 Wilkins Ave., Port Chester, N. Y.
Standard Elec. Mfg. Co., Inc., Haddon Ave., West Berlin, N. J.
Standard Lime & Stone Co., First National Bank Bldg., Baltimore, Md.
Standard Metal Mfg. Co., Malinta, Ohio.
Standard Oil Co. of California, 225 Bush St., San Francisco 20, Calif.
Standard Oil Co. (Indiana), 910 S. Michigan Ave., Chicago 80, Ill.
Standard Oil Co. of N. J., 15 W. 51st St., New York 20, N. Y.
Standard Switchboard Co., 140 Noll St., Brooklyn 6, N. Y.
Standard Transformer Co., Warren, Ohio.
Stanley Co., Inc., William W., 401 Broadway, New York 13, N. Y.
Stanley Works, Stanley Electric Tool Div., New Britain, Conn.
Staplex Co., Air Sampler Div., 777 Fifth Ave., Brooklyn 32, N. Y.
Star Brass Works, 1501 Fulford St., Kalamazoo 24F, Mich.
Star Drilling Machine Co., 475 Washington St., Akron 11, Ohio.
Stardrill-Keystone Co., 920 - 17th St., Beaver Falls, Pa.
Star Expansion Bolt Co., 147 Cedar St., New York 6, N. Y.
Star Jack Co., Davisson St., River Grove, Ill.
Star Wire Screen & Iron Works, 2515 San Fernando Rd., Los Angeles 65, Calif.
States Co., 7 New Park Ave., Hartford, Conn.
Stearns Magnetic, Inc., 635 S. 28th St., Milwaukee, Wis.
Stearns Roger Mfg. Co., 660 Bannock, St., Denver 4, Colo. ADV. p 130
Steber Mfg. Co., 2700 Roosevelt Rd., Broadview, Ill.
Steel Built Construction Co., 1260 Carol St., Bridgeville, Pa.
Steel City Electric Co., 1207 Columbus Ave., Pittsburgh 12, Pa.
Steelcraft Mfg. Co., 9066 Blue Ash Rd., Rossmoyne, Cincinnati, Ohio.
Steelduct Co., Republic Bldg., Youngstown 3, Ohio.
Stein, Hall & Co., Inc., 285 Madison Ave., New York, N. Y.
Stephan Corp., 2022 Broadway, Sacramento 18, Calif.
Stephens-Adamson Mfg. Co., 82 Ridgeway Ave., Aurora, Ill.
Stephenson, Robert C., Rm. 2500, Girard Trust Bldg., Philadelphia 2, Pa.
Sterling Battery Co., 8815 E. Tremont Ave., New York, N. Y.
Sterling Electric Motors, Inc., Telegraph Rd. at Atlantic Blvd., Los Angeles 22.
Sterling Engine Co., Buffalo, N. Y.
Sterling Machinery Corp., 411 Southwest Blvd., Kansas City 8, Mo.
Sterling Motors Corp., 2021 S. 54th St., Milwaukee 1, Wis.
Sterling Steel Casting Co., P.O. Box 230, East St. Louis, Ill. ADV. p 161
Sterling Varnish Co., Haysville, Pa.
Steward & Romaine Mfg. Co., 124 N. 6th St., Philadelphia 6, Pa.
Stewart-Warner Corp., Alemite Div., 1826 Diversey Parkway, Chicago 14, Ill.
Still, Arthur R., Box 1512, Prescott, Ariz.
Stimmel Winch Co., 37-24 - 33rd St., Long Island City, N. Y.
St. Louis Malleable Casting Co., 7701 N. Conduit Ave., St. Louis 15, Mo.
St. Louis Screw & Bolt Co., 6900 North Broadway, St. Louis 15, Mo.
Stockham Valves & Fittings, Birmingham, Ala.
Stockton Iron Works, Harrison & Lindsay Sts., Stockton, Calif.
Stoody Co., P. O. Box 901, Whittier, Calif. ADV. p 103
Stowell & Co., W. H., W. 421 Sprague Ave., Spokane 8, Wash.
Stratoflex, Inc., P. O. Box 10398, Fort Worth, Tex.
Straub Mfg. Co., Inc., 8383 Baldwin St., Oakland 21, Calif. ADV. p 183
Strauss & Co., Inc., A., 17 State St., N. Y.
Streeter-Amet Co., 4107 Ravenswood Ave., Chicago, Ill.
St. Regis Paper Co., Panelyte Div., 230 Park Ave., New York, N. Y.
Stroh Process Steel Co., 1428 High St., Pittsburgh, 12 Pa.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester 3, N. Y.
Strom Steel Ball Co., 1850 S. 54th Ave., Chicago 50, Ill.
Strong, Carlisle & Hammond Co., 1392 W. 3rd St., Cleveland 13, Ohio.
Strong Steel Foundry Co., Hertel & Norris Ave., Buffalo 7, N. Y.
Struthers-Dunn, Inc., Clark Blvd., Philadelphia 7, Pa.
Stulz-Sickles Co., 134 Lafayette St., Newark 5, N. J.
Sturtevant Mill Co., 103 Clayton St., Boston 22, Mass.
Sunbury Wire Rope Mfg. Co., 880 South Second St., Sunbury, Pa.
Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.
Superior Carbon Products, Inc., 9116 George Ave., Cleveland 5, Ohio.

Superior-Lidgerwood-Mundy Corp., 1101 John Ave., Superior, Wis.
Superior Oxy-Acetylene Machine Co., 1102 High St., Hamilton, Ohio.
Sutphen, Peter O., Box 58, Everett, Pa.
Sutton, Steele & Steele, Inc., 1031 S. Haskell St., Dallas 10, Tex.
Suverkrop Instruments, Bakersfield, Calif.
Swaby Mfg. Co., 2330 W. Cermak Rd., Chicago 8, Ill.
Swan-Finch Oil Corp., 285 Madison Ave., New York 17, N. Y.
Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.
Sweet's Steel Co., 770 Sweet St., Williamsport, Pa.
Swett Iron Works, A. L., 158 Glenwood Ave., Medina, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Synthane Corp., River Rd., Oaks, Pa.
Syntron Co., 510 Lexington, Homer City, Pa.

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Tagliabue Instruments Div., Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Talbert Construction Equipment Co., Lyons, Ill.
Talcott, Inc., W. O. & M. W., 81 Sabin St., Providence, R. I.
Talk-A-Phone Co., 1512 South Pulaski Rd., Chicago 23, Ill.
Taller & Cooper, Inc., 75 Front St., Brooklyn, N. Y.
Tamping Bag Co., 218 S. 3rd St., Mt. Vernon, Ill.
Taylor Chain Co., S. G., 141st & Ind. Harbor Belt Tracks, Hammond, Ind.
Taylor & Co., W. A., 7300 York Rd., Baltimore 4, Md.,
Taylor Fibre Co., Norristown, Pa.
Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.
Taylor Instrument Cos., 100 Ames St., Rochester 1, N. Y.
Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Technical Associates, 3730 San Fernando Road, Glendale 4, Calif.
Telluride Iron Works Co., 400 Main Ave., Durango, Colo.
Tema, N. V., 1 Nassaulaan, 'S-Gravenhage, Holland.
Templeton, Kenly & Co., 16th & Gardner Rd., Broadview, Ill.
Tennant Sons & Co., C. of New York, 100 Park Ave., New York 17, N.Y.
Tennant Sons & Co., C. of New York, Sink & Float Div., 100 Park Ave., New York 17, N.Y. ADV. p 196
Tennessee Products & Chemical Corp., 512 First American National Bank Bldg., Nashville 3, Tenn.
Terry Steam Turbine Co., 874 Windsor St., Hartford, Conn.
Texas Co., The, 135 E. 42nd St., New York 17, N. Y.
Texas Foundries, Inc., Lufkin, Texas.
Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Tex.
Thermoid Co., Industrial Div., Whitehead Rd., Trenton 6, N. J.
Thew Shovel Co., Lorain, Ohio.
Theiman Harvester Co., Albert City, Iowa
Thomas & Betts Co., 36 Butler St., Elizabeth 1, N. J.
Thomas Flexible Coupling Co., Warren, Pa.
Thomas Foundries, Inc., 3800 Tenth Ave. North, Birmingham 1, Ala.
Thompson Balance Co., 808—20th St., Denver, Colo.
Thompson Products, Ltd., St. Catharines, Ontario, Canada.
Thompson-Starrett Co., Inc., Roberts & Schaefer Co., 130 North Wells St., Chicago 1, Ill.
Thor Power Tool Co., 175 N. State St., Aurora, Ill.
Throwaway Bit Corp., 4200 N. W. Yeon Ave., Portland 10, Ore.
Thumes Mek. Vaerksted, A. S., Oslo, Norway.
Thurman Machine Co., 156 N. 5th St., Columbus, Ohio.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia, 44, Pa.
Tide Water Associated Oil Co., 17 Battery Place, New York 4, N. Y.
Timken Roller Bearing Co., 1835 Dueber Ave., S. W., Canton 6, Ohio.
Timken Roller Bearing Co., Detroit Axle Div., 100 Clark Ave., Detroit, Mich.
Tinney Drilling Co., 113 W. Main St., Grafton, W. Va. ADV. p 184
Titan Chain Saws, Inc., 2700 Fourth Ave., South, Seattle 4, Wash.
Titan Metal Mfg. Co., Bellefonte, Pa.
Titeflex, Inc., 502 Frelinghuysen Ave., Newark 5, N. J.
Toledo Pipe Threading Machine Co., 1445 Summit Ave., Toledo 4, Ohio.
Toledo Scale Co., 1002 Telegraph Rd., Toledo 1, Ohio.
Tolman Mfg. Co., 19 W. 3rd St., Boston.
Ton-Tex Corp., 247 Pearl St., N. W., Grand Rapids 2, Mich.
Tool Steel Gear & Pinion Co., 211 Township Ave., Cincinnati 16, Ohio.
Tooth Co., H. & L., 1540 South Greenwood Ave., Montebello, Calif.
Torcon Corp., 493 E. 5th St., Ashtabula, Ohio.
Torrington Co., 59 Field St., Torrington, Conn.
Torrington Co., Bantam Bearings Div., 3702 West Sample St., South Bend 21, Ind.
Torsion Balance Co., 92 Reade St., N. Y.
Tour & Co., Sam, 44 Trinity Pl., N. Y.
Trabon Engineering Corp., 1814 E. 40th St., Cleveland 3, Ohio.
Tracerlab, Inc., 130 High St., Boston 10.
Trackson Co., 3333 S. Chase Ave., Milwaukee 1, Wis.
Tractometire Corp., 101 W. Sandusky St., Findlay, Ohio.
Tractomotive Corp., County Line Rd., Deerfield, Ill.
Tracy Co., Bertrand P., Pittsburgh, Pa.
Transall, Inc., 109 N. 11th St., Birmingham 4, Ala.
Transport Trailers, Inc., 1230 - 12th St., S.W., Cedar Rapids, Iowa.
Transue & Williams Steel Forging Corp., 562 W. Ely St., Alliance, Ohio
Traylor Engineering & Mfg. Co., Allentown, Pa.
Treadwell Co., M. H., 140 Cedar St., New York 6, N.Y. ADV. p 155
Treadwell Engineering Co., Easton, Pa.
Trent, Inc., 201-299 Leverington Ave., Philadelphia 27, Pa.
Triangle Conduit & Cable Co., Triangle & Jersey Aves., New Brunswick, N. J.
Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee 12, Wis.
Trojan Powder Co., 17 N. 7th St., Allentown, Pa.
Trombetta Solenoid Co., 329 N. Milwaukee St., Milwaukee 2, Wis.
Trotter & Co., E. T., 594 Johnson Ave., Brooklyn, N. Y.
Troy Engine & Machine Co., 3 Railroad Ave., Troy, Pa.
Truck Engineering Corp., 1285 W. 70th St., Cleveland 2, Ohio.
Truflo Fan Company, Harmony, Pa.
Turner Halsey Co., 40 Worth St., N. Y.
Turner & Haws Engineering Co., 87 Gardner St., West Roxbury 32, Mass.
Turner, Ralph S., Kentucky & Orleans Sts., Bellingham, Wash.
Tweco Products Co., P. O. Box 666, Wichita 1, Kan.
Twin Disc Clutch Co., Racine, Wis.
Twining Laboratories, 2527 Fresno St., Fresno, Calif.
Tyler Co., W. S., 3615 Superior Ave., Cleveland 14, Ohio.
Tyson Bearing Corp., Massillon, Ohio

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Uehling Instrument Co., 473 Getty Ave., Paterson 3, N. J.
Ultrasonic Corp., Monitor Controller Div., Cambridge, Mass.
Ultra-Violet Products, Inc., 145 Pasadena Ave., South Pasadena, Calif.
Una Welding, Inc., 1615 Collamer Ave., Cleveland 10, Ohio.
Union Asbestos & Rubber Co., 1811-33 S. 54th Ave., Cicero 50, Ill.
Union Bag & Paper Corp., 233 Broadway, New York, N. Y.
Union Carbide & Carbon Corp., Electro Metallurgical Co. Div., 30 East 42nd St., New York, N. Y.
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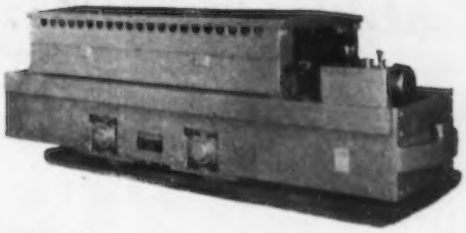

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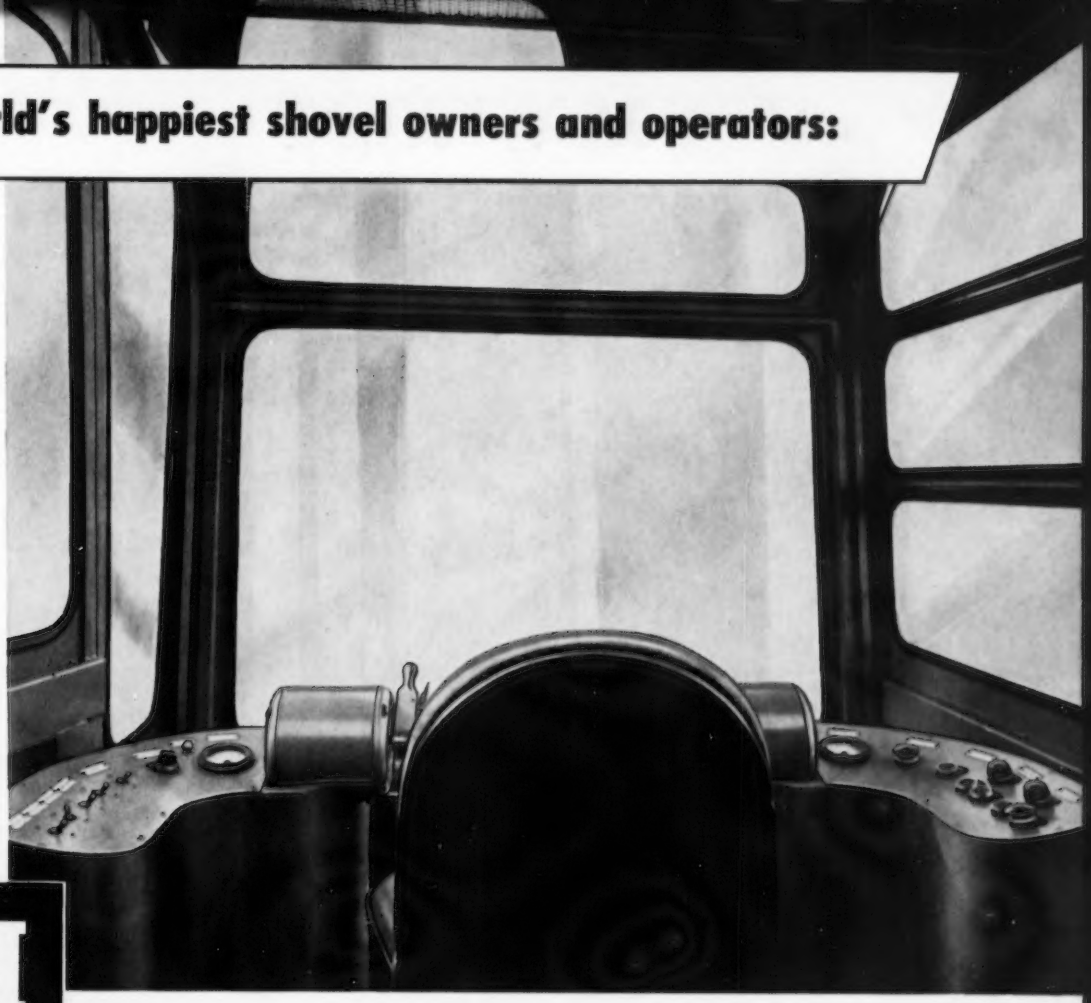

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P&H ELECTRIC SHOVEL DIVISION

HARNISCHFEGER CORPORATION

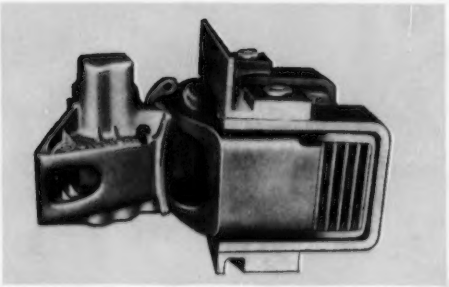
MILWAUKEE 46, WISCONSIN

the P&H Line

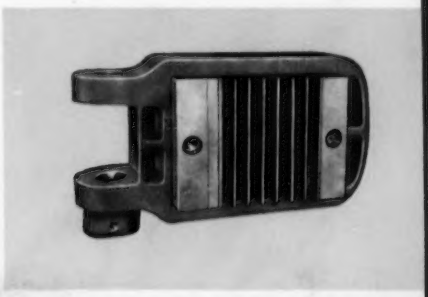
NATIONAL equipment cuts per-ton costs

NC-1 MINE CAR TRUCK is the latest example of National's pioneering in better equipment. Among NC-1 truck advantages are longer and softer ride springs, friction damping mechanism that controls vertical and transverse oscillations, automatic frame alignment and cast one-piece bolster with large lubricated center bearing. A-9821

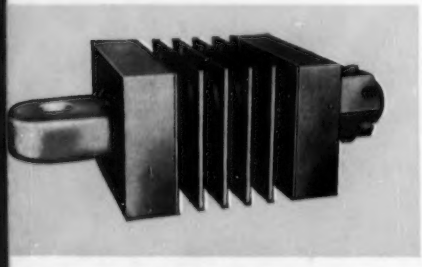
WILLISON AUTOMATIC COUPLERS save time with maximum safety, couple at either end of car or locomotive, require no manual assistance, eliminate damaging slack, permit high speeds with maximum stability.



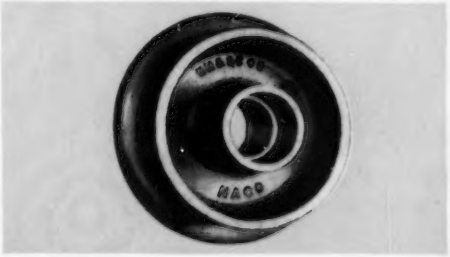
NATIONAL MI-235 Rubber-Cushioned Draft Gear primarily used in Willison spherical-horn coupler assemblies for drop-bottom cars and locomotives; are effective with link and pin bumpers and in strap yokes.



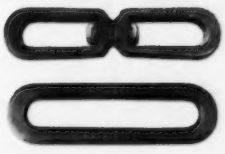
NATIONAL MI-225 Rubber-Cushioned Draft Gear for locomotives and large capacity cars not required to operate through rotary dump. Give maximum impact protection in minimum space.



NATIONAL MI-230 Rubber-Cushioned Draft Gear for cars in rotary dump service. High-capacity rubber pads with soft initial action provide maximum impact protection, lengthen equipment life. Available in capacities and designs to fit individual requirements.

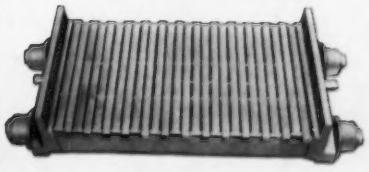


NACO STEEL WHEELS, made from quality-controlled Naco cast steel—of high yield point, great tensile strength and ductility—reduce tread spalling or flange breaking. Available in all sizes regularly used in mining or industrial operations.



NACO STEEL SWIVEL HITCHING AND LINK

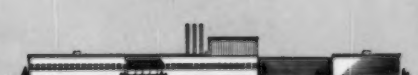
CAST ALLOY STEEL ORE-GRINDING BALLS



CAST STEEL PALLET AND MALLIX SINTERING BARS

NATIONAL MALLEABLE AND STEEL CASTINGS COMPANY • Cleveland 6, Ohio

Technical Center



"Progress through Research"